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DECADE IV. VOL. IX.

JANUARY—DECEMBER, 1902.

THE

GEOLOGICAL MAGAZINE

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WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

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EDITED BY

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Yours very truly,

Henry Woodward.

THE

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NEW SERIES. DECADE IV. VOL. IX.

No. I.—JANUARY, 1902.

THE RETIREMENT OF DR. HENRY WOODWARD.

(WITH A PORTRAIT, PLATE I.)

THE retirement of its Editor from official life, after a period of more than 43 years spent in the public service, is an event which should not be passed over in silence in this Magazine. And during his absence from England the opportunity may be taken to remind both its geological and zoological readers (no one at the present day, we presume, desires to be called a palæontologist) how deeply they are indebted to Dr. Woodward for conducting the GEOLOGICAL MAGAZINE for the long period it has been under his charge as Editor-in-chief. For those who have no regular official duties, which must take precedence of all else, the task of editing a monthly scientific journal, and supplying, when necessary, 'copy' from their own pens to fill gaps, is no light one; but it is one that can be described by no other word than irksome when it has to be performed while running in official harness. Nevertheless, since 1865 the Editor has conscientiously carried on this labour from month to month and from year to year without complaint—and to the satisfaction, we believe, of all his numerous readers. Punctually at the commencement of each month the GEOLOGICAL MAGAZINE makes its appearance; and we trust that it may long continue to do so under the same able editorship.

After its 'coming of age' in 1885, full reference was made in its pages to the Editor's connection with this journal.[1] And it will be unnecessary, therefore, on this occasion to repeat the eulogium then passed by Professor Bonney, except to add that since that date more than fifteen extra years of editorial work have been accomplished. If, as Dr. Bonney said, geologists and zoologists were at that time under a heavy load of debt to Dr. Woodward, their obligations must now be enormously increased.

As some indication of the amount of work, apart from editing this journal, that has been accomplished by Dr. Woodward, it may be mentioned that up to the year 1897 the list of his more important memoirs, papers, and addresses (a few written in conjunction with

[1] GEOL. MAG., 1886, p. 45.

Professor T. R. Jones) totalled 264; by this time they are probably little, if at all, short of 300.

But since on this occasion it is our intention to dwell on Dr. Woodward's connection with the British Museum, rather than with his general work and his editorship of this Magazine, we may pass on to our main subject.

Dr. Woodward first joined the staff of the Museum at Bloomsbury in 1858. The following year he was promoted, and he received a step in 1865 and again in 1867. In June, 1880, on the retirement of Mr. G. R. Waterhouse, he was appointed Keeper of the Department of Geology; and since that date, with his Assistants, he has achieved the task of rearranging the entire Geological Collection in the galleries of the Natural History Museum, Cromwell Road, where, by the aid of popular and well-illustrated guidebooks, diagrams, and descriptive labels, the scientific student, and even the ordinary visitor, can readily derive instruction from the objects displayed in the cases. How much hard work and patience are required for a task of this nature, and what varied kinds of knowledge are necessary in order to bring it to a satisfactory conclusion (or, rather, to keep the Museum up to date), only those who have tried it can judge.

The first edition of the Guidebook to the Geological Department was issued under Dr. Woodward's superintendence in 1881; and since that date each new edition has been expanded and improved. The Guidebook is, of course, for the benefit of the general public, who have, as taxpayers, the first claim on the Museum. But the needs of scientific workers have by no means been neglected, and to Dr. Woodward is due the credit of having initiated in the Geological Department the issue of 'Catalogues' like those which previously proved so valuable to the students of recent zoology. Since 1881 a large number of these Catalogues have appeared under his supervision; how important these are to workers in the life-history of our globe, readers of the GEOLOGICAL MAGAZINE do not require to be informed.

It may be added that, according to the rules of the Civil Service, Dr. Woodward's time of service expired more than four years ago; but, upon the recommendation of the Trustees of the Museum, the Treasury twice sanctioned an extension of his period of service. We learn, moreover, that they have approved of his employment for a year longer on special work connected with the Museum. We also understand that at their meeting on November 23rd the Trustees passed a vote of thanks to Dr. Woodward on his retirement from the office of Keeper for the great services he had rendered during a period of nearly 44 years to the Geological Department.

Readers of this Magazine will, we feel sure, join in wishing Dr. Woodward health and happiness in the comparative rest he has so well earned; and they will be pleased also to have a copy of his portrait, which we have the privilege of inserting.

R. L.

ORIGINAL ARTICLES.

I.—Fossils from the Hindu Khoosh.

By Lieut.-Gen. C. A. McMahon, F.R.S., F.G.S., and W. H. Hudleston, M.A., F.R.S., F.L.S., F.G.S.

Part I.—Fossil Beds and Associated Rocks at Chitral. By General McMahon.

THE fossils described by Mr. Hudleston, F.R.S., in Part II of this paper, were found by Captain B. E. N. Gurdon, C.I.E., D.S.O., Assistant Political Agent, Chitral, on the right bank of the Chitral river, between Chitral and Mastuj. The spot where they were collected is indicated by a small cross marked on the accompanying sketch-map (Fig. 1), which has been based on the map of the Pamirs compiled under the direction of the Right Hon. G. N. (now Lord) Curzon to illustrate a paper by him published in the Journal of R.G.S. of 1890.[1] My son, Major A. H. McMahon, C.S.I., C.I.E., F.G.S., in company with Captain Gurdon, visited Mastuj in October, 1900. He indicates the strata in which the fossils were found as follows:—

"As regards the fossils, they all come from a bed of limestone exposed in a cliff on the right bank of the Chitral river, *immediately* opposite Reshun. Reshun itself is on the left bank of the river, about half-way between Mastuj and Chitral. It is, by the way, the place where Edwards and Fowler made their brilliant defence and were treacherously taken prisoners in 1895.

"This year, after my arrival at Chitral, I made a flying tour of treble marches and more a day, from Chitral to near Mastuj and back, and give you the result of such geological observations as I was able to make. From Dir[2] northwards, I use the names given in Curzon's map.

1. "At Malakand itself there is a broad, nearly vertical dyke, of white granite, about a hundred yards wide, which runs nearly E.N.E.-W.S.W. Between Ashreth and Mirkandi there is a great deal of granite. Owing to the vegetation and surface soil it is hard to tell the direction of the strike. At a point between Ashreth and Mirkandi granite disappears, and I have seen no more traces of it *in sitû* northwards in Chitral.

2. "Just before coming to Mirkandi I noticed some conglomerate, and I think there is a bed of it here, but I am not sure owing to vegetation and surface soil. I have marked its probable line of outcrop on the accompanying diagrammatical sketch (Fig. 2, Bed 1).

3. "Close to Mirkandi, on the opposite bank of the river, a bed of red sandstone rock crops out, like the red sandstone near Yasin, described at p. 358, vol. lvi, Q.J.G.S. This runs, as shown in the diagrammatic sketch (Fig. 2), past the back of Kala Drosh (see Fig. 2, Bed 2).

[1] Published as a separate map by Edward Stanford, Charing Cross.
[2] Dir is about nine miles south of the Lowari Pass, marked on sketch-map, Fig. 1.

4. "In the cliff opposite Gairat is exposed a bed of grey limestone which looks exactly like the grey limestone from the Gilgit-Kilik and Gilgit-Darkot series. This bed runs in a clearly defined direction, as shown in Fig. 2, Bed 3. Some of this limestone smells of sulphuretted hydrogen when struck with a hammer.

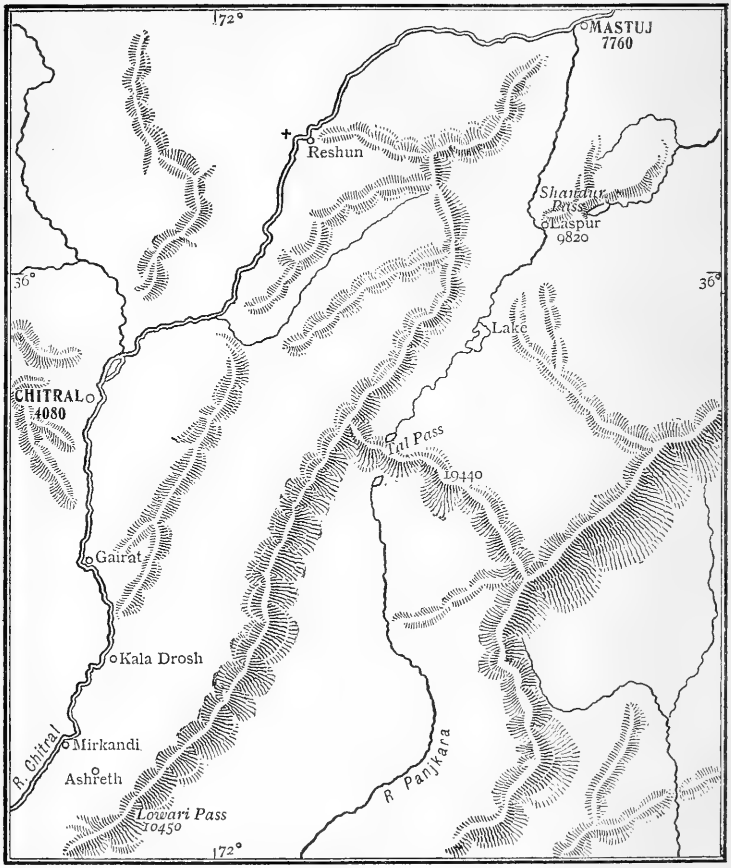

Fig. 1.

5. "Below Reshun a bed of conglomerate crosses the river and runs as shown in the diagrammatical sketch (Fig. 2, Bed 1). The conglomerate is very tough and is traversed by numerous white quartz veins, which pass through the matrix and pebbles, without being diverted from its course by the latter. The pebbles and boulders in the conglomerate are subangular to rounded, and vary much in size and colour.

6. "Just below Reshun, among other beds, one of red sandstone

runs parallel to the conglomerate, and crosses the river, as shown in Fig. 2 (Fig. 2, Bed 2). It is similar to the bed alluded to above.

7. "Opposite Reshun, on the west or right bank of the river, a bed of grey limestone is exposed, which runs parallel to the conglomerate and red sandstone. The fossils found by Captain Gurdon and described in Part II of this paper were taken from this bed of limestone opposite Reshun.

8. "You will see that there are two sets of parallel beds, in ascending order, each set containing a conglomerate, red sandstone, and limestone, as shown roughly in Fig. 2. I am inclined to think that if the beds were followed along their course they would be found to constitute one and the same series, and consequently that there are not two separate sets of parallel beds. Further, I think it not improbable that this group of parallel beds of red sandstone and limestone will be found to be a continuation of those noted by me near Yasin, and again in the Hanza Valley."[1]

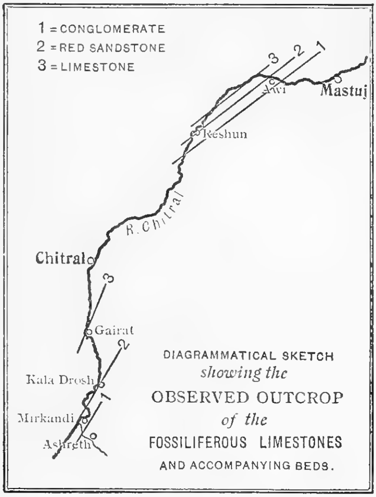

Fig. 2.

In these views I quite concur with my son. There is no evidence of faulting, whilst bending of the strata in the direction of the line of strike is so common in the north-west Himalayas, that this explanation seems to be all that is required to account for the slight divergence in the direction of the strike shown in Fig. 2. The discovery near Chitral of a conglomerate of the character detailed above, associated with a sandstone and a limestone, is interesting to the Himalayan geologist, and it may lead to important results. The triune band described above recalls the Blaini group of the Simla area, which also consists of a peculiar conglomerate, a limestone, and a quartzite;[2] "a band," in the words of Mr. Medlicott,

[1] See paper on Geology of Gilgit, Q.J.G.S., vol. lvi, p. 337.

[2] Medlicott: Memoirs G.S.I., 1865, vol. iii, p. 30.

their discoverer, "that is very peculiar and characteristic, and which can be traced without any doubt to great distances." Mr. Medlicott adds: "This band promises to be of special utility in identifying rocks in the interior, with those of the outer parts of the lower Himalayan region."

The principal members of the group are the conglomerate and the limestone. The conglomerate appears below the limestone[1] in the Simla area, and this sequence is that observed in the Chitral region.

Mr. Medlicott, in his description of the typical Blaini area,[2] notes that "as an irregular accompaniment of these Blaini beds" (namely, the conglomerate and limestone) "I must mention a clear coarse quartzite: at two or three points in the lower course of the Blaini, this bed shows apparently over the limestone." In the Blaini river this "irregular accompaniment" "apparently" occurs above the limestone, but in the Chitral region a red sandstone appears below the limestone. The Chitral red sandstone therefore cannot be a lateral extension of the particular beds seen at Simla; but as Chitral is about 450 miles distant as the bird flies from the Blaini river, it is hardly a matter of surprise that the local conditions of the two places should not have been precisely alike during the Blaini age, and that arenaceous deposits should have been laid down at slightly different horizons at Chitral and Simla.

The red sandstone bed of Chitral, which is associated with a limestone, has been detected in several places in the Gilgit area, and has been described in my paper on that region.[3] As the red colour of this bed naturally strikes the eye of an observer, the bed may prove valuable in leading to the identification of the group of which it is a member in adjoining areas.

My son did not detect the Blaini conglomerate in the Gilgit area, but as his attention had not then been directed to this rock, he thinks it possible that it may hereafter be found in that region. He thought at the time that the conglomerates he came across were probably of glacial origin. It may, moreover, be a work of considerable difficulty to detect the Blaini conglomerate in the Gilgit area, if it occurs there. Gilgit is a region of intense metamorphism, and the conglomerate may there be metamorphosed almost out of recognition. Even in the comparatively unaltered area of Dalhousie, the conglomerate has become schistose and foliated.[4] Moreover, the pebbles imbedded in the matrix of the conglomerate are sometimes locally very sparse; and when this is the case, the difficulty of detecting the rock in a highly metamorphosed area would be greatly increased.

My son's description of the Chitral conglomerate corresponds with the appearance of the Blaini rock in many places in the Simla and Dalhousie districts. The pebbles of the Chitral conglomerate are more or less rounded, and vary much in size and

[1] Medlicott: Memoirs G.S.I., 1865, vol. iii, p. 30. McMahon: Records G.S.I., 1877, vol. x, p. 207. [2] Loc. cit., p. 31.

[3] Q.J.G.S., vol. lvi, p. 358.

[4] McMahon: Records G.S.I., 1881, vol. xiv, p. 306.

colour. "Many of them," my son writes, "are green, like the green specimens of rocks I sent from the Gilgit district." In my account of the Blaini conglomerate at Dalhousie[1] I note that the white pebbles in the matrix are "of various sizes up to nine inches in diameter. The rock also contains grey and blue quartzite, and quartzite-sandstone pebbles, subangular to rounded, which weather various colours." The matrix of the Dalhousie conglomerate is a hard slaty schistose rock, whilst my son notes that the Chitral rock is too tough and hard to break with a hammer. He also mentions that the matrix of the Chitral rock has an igneous appearance, which has its counterpart in the Blaini rock as seen in eastern Sirmur, where the matrix of the conglomerate resembles a volcanic ash, and the whole rock a volcanic breccia.[2]

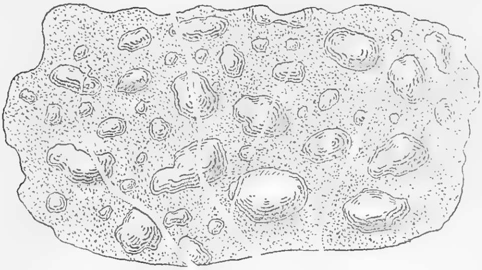

FIG. 3.—Chitral conglomerate with quartz veins.

The circumstance noted above, that the Chitral conglomerate is traversed by quartz veins, which penetrate the matrix and pebbles indifferently, is one that I have often observed in the Simla area. I have within the last few days received from Captain Gurdon, large specimens of the Chitral conglomerate, which were obtained by blasting the rock. (Fig. 3.)

The specimens contain very numerous pebbles, varying greatly in size up to $3\frac{1}{4}$ inches in length; they are mainly subangular, but many are rounded and a few are angular. The matrix is an indurated, fine-grained, slaty grit, or arenaceous mudstone. The pebbles consist of limestones, slates, sandstones, and quartzites, and there are some rounded white quartz pebbles, which recall the 'eggs' of the Simla rock, but are much smaller. The whole rock is deeply impregnated with carbonate of lime, probably due to infiltration from the adjacent limestone.

The Blaini group has a remarkably wide extension. It has been traced to Mussoori,[3] and a conglomerate resembling it has been observed as far east as Manipur.[4] In its westward extension I followed it through a large part of the Chamba State,[5] and it

[1] Loc. cit., p. 306.
[2] Oldham: Man. Geol. India, 2nd ed., p. 132.
[3] Man. Geol. India, 2nd ed., p. 133.
[4] Loc. cit., p. 148.
[5] Records G.S.I., vol. xiv, p. 305; vol. xviii, pp. 35, 79.

was traced by Dr. Hutchison through north-east Chamba into Lahoul.[1] The occurrence of the conglomerate has been noticed by Mr. Lydekker, F.R.S., in numerous places in Kashmir.[2] There is no *primâ facie* improbability, therefore, that representatives of the Blaini series should occur in Chitral and Gilgit. Should subsequent observations confirm my suggestion that the Chitral band of conglomerate, red sandstone, and limestone represents the Blaini series, the fact will be of great importance. The conglomerate and red sandstone are striking rocks, capable of easy recognition, and will afford a definite geological horizon in adjacent areas, where intense metamorphism has obliterated fossil evidence.

The Blaini beds, which in the Simla district are unfossiliferous, were originally regarded as of Upper Silurian age[3] at the suggestion of Dr. Stoliczka, who regarded the Muth beds[4] of Spiti as the equivalents of the Blaini series of Simla. Subsequently the Blaini conglomerate was supposed to represent the Salt Range conglomerate and the Talchia boulder bed, and was considered to be of Carboniferous or Permian age.[5]

The age of the Chitral limestone has now been determined by Mr. Hudleston, on the evidence of well-preserved fossils; and it remains to future observers in the field to work out the important question, whether or not the Chitral band of conglomerate, red sandstone, and limestone truly represents the Blaini group of the Simla area. If it does, as I suggest, Mr. Hudleston's investigations will have the important result, not only of determining the age of the Chitral beds, but of supplying an easily recognizable horizon for the elucidation of a widespread area in the north-west Himalayas.

The Chitral region, I remark in conclusion, is one of the most difficult in the world for detailed geological exploration. The frontier tribes are not to be trusted; the mountains are very lofty; the gorges deep and narrow, and profound precipices are of frequent occurrence.

II.—Moraines and Mud-streams in the Alps.

By Canon T. G. Bonney, D.Sc., LL.D., F.R.S.

It has often occurred to me during my Alpine wanderings that masses of earthy material containing boulders are too readily identified as moraines. That the latter exist, both here and in other mountain regions, no one would for a moment dispute, but deposits, sometimes very closely resembling till, may be produced in other ways. One is by a bergfall. The result of this in some cases, as at Goldau, Plurs, near San Vito (Ampezzo road), or the Col de Cheville, can be easily recognized; but when the fallen material consists largely

[1] Loc. cit., vol. xviii, p. 90.
[2] Memoirs G.S.I., vol. xxii; Records G.S.I., vols. ix, xi–xv.
[3] Oldham: Man. Geol. India, 2nd ed., p. 137. Records G.S.I., vol. xiv, p. 307.
[4] A red quartz conglomerate is a prominent member of the Muth series. Memoirs G.S.I., vol. v, p. 22.
[5] Man. Geol. India, p. 137; Memoirs G.S.I., vol. xxiii, p. 54.

of shale and friable rock, when there is a certain admixture of boulders from a distance (formerly perched blocks), its origin is not so readily determined. The enormous mass of débris on the north bank of the Rheinthal, between Chur and Ilanz—a mass which extends from Digg, through Flims, to rather beyond Laax, consisting of earthy stuff, probably mainly smashed shale or slate, and of boulders, apparently limestone—is regarded as bergfall by the Swiss geologists, and yet any section in it might readily be taken for moraine. Even more moraine-like in general aspect are the singular mounds of débris in the valley of the Rhone near Sierre. These consist of a clayey material full of small rock fragments, angular and subangular, which are generally less than an inch in diameter, and seldom exceed four or five inches, though now and then a large boulder occurs. Of these fragments the majority are dark limestone, sometimes slaty; a small proportion, generally more water-worn, being gneiss or schist. These mounds are regarded as the relics of a great bergfall, but were it not for the paucity of crystalline rock, especially among the boulders, they might well be passed as moraines, for their relation to the slope down which the material has descended is not obvious at a glance.

The débris deposited by flooded torrents often closely resembles moraine. I may quote a few instances from my own experience. At Zinal in July, 1895, we heard, late one evening, an extraordinary roaring noise, which proved to be caused by the descent of a mass of grit and boulders mingled with water, which had issued from a glen on the eastern flank of the valley.[1] This formed a great fan of débris (not very unlike moraine, except perhaps subangular fragments were commoner), which had flowed down to the river. I once actually watched a similar occurrence, the result of a violent rainstorm, at Les Ouches, near Chamonix. Thousands of cubic feet of black liquid mud and broken shale or slate came sweeping down a gully and buried the high road for some distance. I passed over another discharge of flood débris in the Zillerthal a few days after it had descended. Here the valley was rather broad, the carriage-road running along it near the lowest part. The discharge, which had been caused by a local 'cloud-burst,' had come from the mountain slopes on the left bank and had followed the path of two small streams. The first had affected the larger area, having buried everything—road, gardens, fields, thickets—under a mass of débris, a mixture of mud and rock fragments, small and large. There were hundreds, nay, thousands of blocks, in shape and size like portmanteaux. A wooden chalet had been torn up and swept along like an empty packing-case for about 200 yards. Here, though no doubt could arise as to the nature of the deposit, the material itself was not very unlike a moraine of the lowlands. Again, the road and the railway in the Rhone Valley near Monthey cut through an enormous mass of material, which might easily be taken for moraine, as it is a mixture of mud and rock fragments of various

[1] I was informed that the stream, some two or three thousand feet above Zinal, had been dammed by a slight landslip till the ponded-back water burst the barrier.

size, some being nearly a hundred cubic yards in volume. This, which descended in August, 1835,[1] after unusually heavy rains, appears to have been started by the fall of a large mass from the crags of the Dent du Midi, which was augmented on its course by snow and rock débris, and rendered more liquid by swollen torrents, till it descended to the Rhone like a stream of lava. These instances may suffice, though it would be easy to add to their number.[2]

Mud avalanches and fans of débris are on a grander scale in the mountains of Hindustan. Sir Martin Conway mentions them in his well-known book "Climbing in the Himalayas." For instance (p. 127), the valley of the Indus near Bunji is broad and flat-bottomed; on the western side "is a mighty wall of rock, on the eastern it is bordered by steep slopes." The slopes and the wall, he thinks, cannot meet at a less depth than 500 feet below the bed of the valley, and not improbably at one much greater. "By what processes were these vast débris accumulations brought together? The problem is of general interest, for the Bunji valley may be regarded as typical of Central Asian valleys generally, and what is true of it is true also of the Pamir valleys and of those in the regions of Western Tibet and Eastern Turkestan. . . . . It is clear that the valleys have not been filled by the agency of bursting lakes. The gentle dip of the bedding of the débris towards the river proves that the stuff came from the side slopes. . . . . The question arises, How was such a quantity formed and caused to descend? Here the reader must bear in mind the nature of the climate in the regions under consideration; it possesses two main qualities, extraordinary dryness and extreme and rapid variation of temperature. The rainfall is trifling over the whole area, except where the mountains reach great altitudes, and there snow is precipitated in considerable quantity. . . . . Throughout all the region there is constantly being provided a mass of loosened débris such as is never found in the better known mountains of Europe." The low slope of this valley deposit, sometimes barely 3°, and the large area covered, he goes on to say, prevent us from referring it to ordinary bergfall, and makes 'mud avalanches' the only possible explanation. These have been seen actually descending by various travellers—Colonel Godwin-Austen, Sir William Lockhart, Dr. and Mrs. Bullock Workman; indeed, the last named had a rather narrow escape from one.[3] Sir Martin Conway himself saw two come down a gully near the Hispar glacier, one just before, the other just after his party crossed it.[4] "It was a horrid sight. The weight of the mud rolled masses of rock down the gully, turning them over and over like so many pebbles, and they dammed back the muddy torrent and kept it moving slowly but with accumulating volume. Each of the big rocks that formed the vanguard of this avalanche

[1] A summary of the facts will be found in Joanne, "Itinéraire de la Suisse," Route 25 (between St. Maurice and E'vionnaz).

[2] See also Dr. A. Irving, Quart. Journ. Geol. Soc., vol. xliv (1888), p. 158.

[3] "In the Ice World of Himalaya," p. 156.

[4] "Climbing in the Himalayas," p. 323.

weighed many tons; the largest were about ten-foot cubes. The stuff that followed them filled the *nala* to a width of about forty and a depth of about fifteen feet. The thing moved down at a rate of perhaps seven miles an hour. . . . . Looking up the *nala*, we saw the sides of it constantly falling in and their ruins carried down." Finally, the material spread out as a fan on the bed of the valley below.[1] Earth pillars, he observes, are frequently seen to be carved from the older masses.

Thus it is evident that under certain circumstances deposits, which may be termed mud avalanches, do not a little towards filling up the valleys in mountain countries. Such deposits are, I believe, more common in the Alps than is sometimes supposed. In my diary for 1893 I made this note on the valley between Hinterrhein and Splugen:—"A marked feature is the quantity of débris brought down by the lateral torrents, forming alluvial fans cut through by the main river. The stuff is often like moraine, but the stones (ranging from sub-rotund to angular) are more rounded, and there is a considerable quantity of earthy matter, often more than the stones. The deposit exhibits a slight stratification, and reminded me at times of the esker material which I had seen near Parsonstown."[2] It is clear that under certain circumstances this method of accumulation of débris in valleys is most important, and, where not closely studied, might be mistaken for till. Below Andeer, where the valley again opens out, great fans of débris are seen on the left bank, similar to those described above, exhibiting in places fairly marked stratification. The river has exposed a fine section of one on that bank, the cliff being perhaps fifty feet high, and on the opposite side, where the valley is contracting, is another. As the drift can be traced down to the level of the river, the valley must have been excavated to its present level before these fans were deposited. But it is often extremely difficult, when only an isolated section can be obtained, to say whether this is in a mud avalanche or a true moraine.[3]

From these I pass to deposits which have been often claimed as moraines, such as that from which the earth pillars at Useigne, in the Eringerthal, have been sculptured. Very near to these the main valley is joined by the Val d'Hérémence. The deposit, a kind of till in which large boulders are not very numerous, extends some distance into the latter and for more than two miles up the former, occurring first mainly on the left bank, then on the right.[4] Good sections may be frequently seen. In one case, on

[1] See also "The Making of a Frontier," by Colonel A. Durand, pp. 33, 34. (As I have explained in a paper now in the hands of the Geological Society, I think Sir M. Conway's description includes with the mud avalanches a breccia which has a rather different history.)

[2] I had examined this during the previous Summer (1892).

[3] In my diary I have given the facts which make for the one or the other conclusion, but as there is no impossibility that both may occur in this valley I deem it needless to enter into particulars.

[4] It is shown clearly on the Geological Map, where it is marked as "Terrain Glaciaire." The material, from which the actual pillars are carved, is perhaps more directly in the line of the Val d'Hérémence.

the right bank, where there are imperfect pillars, the material seems to be connected with a wide tributary opening, rock appearing opposite to it on the left bank of the river. In the neighbourhood of the pillars (about half a mile below Useigne) the material certainly shows some stratification rudely parallel with the slope of the hill, as in a talus. "It is morainic, not moraine—hillside talus, mud, torrent débris, moraine, perched blocks, all sorts of stuff brought down by rain and stream. It looks as if the valley, after having been excavated to something like its present depth, had been choked up with this mixture."[1] The way in which it is distributed, not in mounds, but forming parts of the slopes descending from either side of the valley, shows that it cannot be true moraine.

The earth pillars near Stalden have a similar origin. These occur on the right bank of the Vispthal, roughly opposite to the steep ascent on the railway before it reaches that village. I came to the conclusion, more than twenty-five years ago, that this material had descended from above, and have been confirmed in it by later study, especially during the past Summer. The pillars have been carved out of a pale grey 'earth,' more or less micaceous, containing some small fragments (but less numerous than in a moraine) with occasional boulders (crystalline rock), now and then large. The annexed diagram, rough though it is, will save a long description.

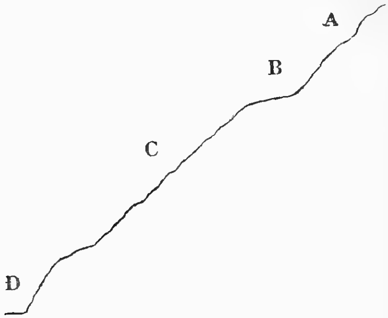

Fig. 1.—Section right bank of Visp near Stalden.

A, mountain side, steep and rather bare, rising for some hundreds of feet and forming the skyline; B, cultivated ground, forming a kind of shelving terrace; C, long slope, with rock showing in the steeper part, on which streamlets (sometimes dry) have cut ravines, on the flanks of which are pillars; D, cliffs above the Visp.

The terrace bank, thus furrowed, extends for some hundreds of yards, and bears no resemblance in form to a moraine either lateral or terminal. But it is not the only instance. Part of Stalden stands on a mound of similar material, through which the railway cuts just before entering the station. At first sight this more

[1] Note written on the spot in 1900, when I saw them again after an interval of twenty-four years.

nearly resembles a moraine in outline, but we find on further examination that it extends some distance up the valley beyond the village, not to mention other difficulties. We have not, however, far to go to obtain much stronger evidence. The lower part of the mountain buttress between the Gorner and the Saas Visp is formed of, or more strictly speaking masked by, identical material, which also has clearly come from above. Looking up the latter valley from the station at Stalden we can see on its right bank, at some distance, another terrace slope of the grey débris, lodged in similar position to that with the pillars. In fact, as we walk up the valley to Saas, we pass by two or three of these deposits; that of which I give a rough diagram being on the left bank, not far from the Boden Brücke. This affords us distinct proof that the débris was

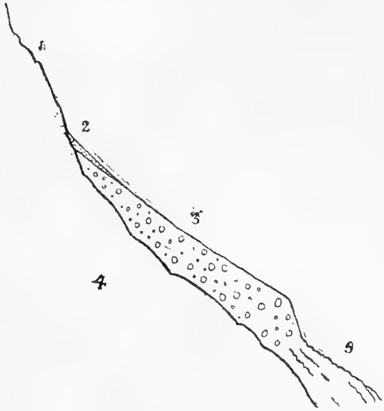

Fig. 2.—Section by the Saas Visp near Boden Brücke.

A diagram constructed from a sketch taken on the mule-track.

(1) Bare rocky crags (gneiss) rising up to the skyline.
(2) Talus of fallen rock.
(3) 'Mud avalanche' material.
(4) Steep bare rock, rounded, smoothed and scored by ice. This, near where I stood, could be traced to within 10 feet of the Visp.
(5) Talus at foot of cliff-face of mud avalanche, overgrown by vegetation descending towards the Visp—which would be nearly an inch below the bottom of the drawing.

deposited after the ice had finally retreated from this part of the valley, that it descended from some part of the mountain above the cliffs which we see from below, and that it was formed under conditions which no longer exist, for its upper part is now buried by a talus of broken rock derived apparently from these cliffs.[1] In no instance is the rock which has supplied the avalanche material

[1] I have little doubt that the Zwerglithurm near the path from Viesch to Eggischorn, figured by Sir C. Lyell ("Principles of Geology," ch. xv), which I examined in 1881, has been carved out of similar material.

visible from the valley, since the upper parts of the mountain are concealed hereabouts by their lower buttresses. But occasional glimpses are obtained of a mass of pale-coloured schists, which no doubt extends for a considerable distance, and is perhaps identical with one which I remember to have seen near the entrance of the Vispthal.

The earth pillars of the Katzenbach and the Finsterbach have long been famous. These are in upland valleys, high above that of the Adige, on the flanks of the Rittnerhorn. As they have been so frequently described, a few words about the material will be sufficient. The matrix is a red earth, which becomes hard in drying, and has probably been supplied by the destruction of the well-known 'porphyry.' Most of the smaller stones are more or less rounded, even the big blocks (up to 50 or 60 cubic feet) being not unfrequently subangular. Stones of any conspicuous size are not very numerous; it would not be difficult to find a cubic foot of material without one bigger than a marble. Once or twice I saw signs of stratification, and the larger boulders seemed often to occur in layers. The relation of these masses of débris to the slopes on either side and to the upper part of the mountain itself satisfied me that the ridges and pillars had not been carved out of mounds, but from material which had been deposited so as to partly fill up a valley already excavated in the 'porphyry.' On my first visit I came to the conclusion, with which my companion, the late Mr. W. Mathews, agreed, and which was strengthened on a second examination nine years afterwards, that this material, though very likely incorporating moraine stuff, was not true moraine, but had descended into the glens from above, and thus was more or less of the nature of mud avalanche.

Though these deposits of muddy débris often are not easily distinguished from true moraines, the question may occasionally be settled at once by the correspondence between the materials and those *in sitû* on the mountain side above; but as these slips (so far as I know) are always later than the final retreat of the ice, they may have carried down with them and incorporated moraine and perched blocks. As a rule, however, in one of these deposits, the finer material bears a larger ratio to the boulders than is usual in true moraines under similar conditions. In them, as far as my observations go, this ratio increases with the distance from the head of the valley. But the material in three, at least, of the districts named above—in the Eringerthal, in the Vispthal, and in the upland valleys on the Rittnerhorn—resembles what we should expect to find in moraines on subalpine or even lowland regions. The form, however, is a more characteristic feature. A moraine in its natural condition is more or less of a mound. These flood deposits either shelve gently up—like all slopes of débris—to the cliffs and glens down which they have descended, or fill up the bed of the main valley to a considerable depth.[1] The latter any ordinary terminal

[1] As is the case with the trass which still remains in places in the Brohlthal (Eifel).

moraine could not do, for if, instead of forming a mound, it trailed along after the retreating ice, it would be comparatively thin. Some glacialists, however, may claim the deposit for ground moraine, which once loomed very large in not a few imaginations, and was defined as "rock rubbish derived from the subjacent rock masses by the ice itself." Such material no doubt exists, but to what extent (as I have repeatedly urged) must be determined by proof, not by hypothesis. Spitzbergen and Greenland were then generally supposed to bear some resemblance to the condition of the Alps in the Great Ice Age. But the researches of Professors Gregory and Garwood in the former, and of Professor Chamberlin with other American observers in the latter, have not been rewarded by the discovery of enormous masses of indubitable ground moraine, exactly resembling the Boulder-clay of Britain and North Germany. Material to which the former term may be applied seems to be produced in one of three ways: (1) in certain cases an advancing glacier pushes before it, more or less levels down, and finally travels, as if along a terrace, over what began as terminal moraine; (2) when a glacier ends in an ice-cliff, fragments from the upper parts of this and rock débris from the top may fall down, become frozen together, and then adhere to the lower part of the advancing mass, by which they are carried down the valley and finally deposited on its rocky floor, when the ice melts away; (3) either this material, or any picked up locally by the glacier as it is moving downwards, may be sometimes distributed by differential movements of the ice in a more or less stratified manner through its lower portion. This approaches nearest to the old ideal of ground moraine; but as that stratification rarely extends for more than a hundred feet from the bottom of the glacier, the material which it has left cannot be very thick.[1] But as an ice-sheet, when moving over nearly level ground, seems not only to be incompetent to erode but even to override loose material, already deposited, one layer, in case of a second advance, might be superposed on another. In the Alps, however, a retreat of the ice is generally signalized in the lower regions by a deposit of stratified gravel, while in the upper the glaciers were obviously able to keep their rock beds tolerably clean. We cannot, therefore, in my opinion, apply this explanation to the deposits under discussion. Morainic—that is, partly composed of ice-deposited material—they may be,[2] but they are not true moraines.

The Alps accordingly appear to have passed through a phase of denudation which is still in process in the Himalayas. In the former, when the snow and ice first disappeared from the zones which are now uncovered for most of the year, the rock would be not only rather thickly sprinkled with morainic débris, but also

[1] So far as I can judge from the excellent illustrations to the papers mentioned above, the débris can hardly amount to one-fifth of the whole mass, so that the former is seldom likely to exceed 20 feet, and would generally be much less.

[2] This, if I mistake not, is included by Continental writers in the term 'Glacial Schotter.'

often without protection from talus-slope or vegetation. It would therefore be more readily affected by changes of temperature, heavy rainfall, and an inclement climate, and thus avalanches or torrents of mud would be on a larger scale than now. As a rather dry climate, according to Sir Martin Conway, is also distinctly favourable to this kind of denudation, it may have been very active in the 'Steppe Age' which probably closed the Glacial Period. But of this we perhaps hardly know enough to do more than venture a suggestion.

III.—The Origin and Progress of the Modern Theory of the Antiquity of Man.

By Sir Henry H. Howorth, K.C.I.E., F.R.S., F.G.S., F.S.A.

When Dr. Woodward asked me a few months ago to review some pamphlets on early Man and his remains, I very reluctantly promised to do so, because I felt that if I were to be frank and sincere I must speak of some recent developments of the study in unsympathetic terms, which would not be welcome in some quarters. I little expected, however, that I should have been overwhelmed by such a shower of peppercorns as I find on my return from Italy was the case in the September number of the Geological Magazine.

If he thinks the subject worth ventilating and sufficiently interesting, Dr. Woodward will perhaps afford me some space in which to deal with my critics, more especially as the issue continues to be, what Haeckel lately called it, the problem of problems. I also wish to correct one or two slips which I made in consequence of having to write so hurriedly before.

My purpose is not so much criticism as to try and disentangle the story of the growth of rational views in regard to the origin of man and to define where the problem now stands. I must deal, therefore, in rather more detail than has hitherto been done with the history of the controversy.

The first rational statement on the question known to me was the famous verse of Lucretius—

> "Arma antiqua, manus, ungues, dentesque fuerunt,
> Et lapides, et item sylvarum fragmina rami.
> Posterius ferri vis est, aerisque reperta;
> Sed prior aeris erat, quam ferri cognitus usus." [1]

This extraordinary statement (considering when it was written) took a long time to fructify. The first actual fact recorded, so far as I know, in support of it, viz. the discovery of the Palæolithic implement found in Grays Inn Lane, was not published until the beginning of the eighteenth century. I gave details about it in my previous paper. The interest of this stone, however, like that of the Cannstadt jawbone found in the loess in 1700, is rather retrospective

[1] "Ancient arms were hands, nails, teeth, and stones and also broken branches of trees. Afterwards the virtue of iron and of bronze was discovered, but the use of bronze preceded that of iron."

than direct. The importance of the discovery in each case was only appreciated and its real lesson learnt at a much later time.

Eckhard, Professor of History at Brunswick, who died in 1730, in his work "De Origine Germanorum," which was not published until twenty years after his death, says, "Lapides armis apud omnes successere aerea" (i.e. "bronze everywhere succeeded stones for arms," op. cit., xlii, p. 81); Borlase, in his "Antiquities of Cornwall," 1753, argued in favour of the three ages of man; while Goguet, in 1758, in his "L'Origine des lois, des arts, et des sciences" (vol. i, book ii, ch. 4, p. 133), says, "All antiquity is agreed that there was a time when the use of metals was unknown in the world." These statements, however, were only echoes of Lucretius.

The first person who argued scientifically that men at one time used stone for their weapons and tools to the exclusion of metal, that is, argued in favour of a Stone Age, was, according to M. Le Hon, Mahud El, who, having examined a considerable number of so-called thunder-stones, i.e. stone axes, urged in 1734 that they were the first instruments made by man at a period when he did not know metal ("L'Homme Fossile," p. 23). Frere, who wrote a good deal later, i.e. in 1797, based his conclusion on certain implements which he had found in the Suffolk gravels. To show how well he had grasped the general conditions of this particular point, I will quote an additional paragraph to that referred to in the previous memoir and cited from his paper in the thirteenth volume of *Archæologia*, p. 103. He says: "The implements lay in great numbers at the depth of about 12 feet in a stratified soil, which was dug for the purpose of raising clay for bricks"; and he concludes: "The situation in which these weapons are found may tempt us to refer them to a very remote period indeed, even beyond that of the present world; but whatever our conjectures on that head may be it will be difficult to account for the stratum in which they lie being covered by another stratum . . . . The manner in which they lie would lead to the persuasion that it was a place of their manufacture, and not of their accidental deposit, and the number of them was so great that the man who carried on the brickwork told me that before he was aware of their being objects of curiosity he had emptied baskets full of them into the ruts of the adjoining road. He concludes that the different strata were laid down by different inundations." So much for Frere.

It was the explorers of caves, however, who first produced evidence that man had existed in Europe when hyænas and lions were still living there; thus, in 1774 Esper, in publishing his account of the cave at Gailenreuth, tells us he had found a jaw and a shoulder-blade of a man mixed with the remains of these animals, and he declared it to be his opinion that these bones were all contemporary. There is no reason to question either Esper's competence as a witness or the fact of the discovery. In 1804 Rosenmuller published an account of his own researches in the same district, and says that he was convinced by the testimony of his own eyes that the bones of men had undoubtedly been found mixed with those of bears and lions in the caves of Gailenreuth. In the year 1700 some extensive excavations were made at Cannstadt in Würtemberg, and a vast number of remains of so-called Pleistocene beasts were found more than a century later. These bones were examined, and a human jaw and some other human remains were found among them. Cuvier, in referring to them in the first edition of his Oss. Foss. in 1812, refused, however, to consider the bones as contemporary.

In the introduction to his "Petrefactenkunden," published in 1820, Schlotheim, who explored the caves at Gailenreuth more minutely, described how in the fissures in the gypsum quarries at Köstritz in Germany human bones had undoubtedly been found with the bones of *Rhinoceros antiquus*, an extinct horse, the great extinct stag, and the fossil hyæna and lion. "Human bones had been recognized there," he tells us, "since the first opening of the quarries thirty years before, and in almost every gypsum quarry in the district." The various bones were found together, assembled in a heap. He argues that these bones could not have come there by way of burial or adventitious falls into the fissures, nor by other accidental causes, but were always found with the other animal remains in the same relations, and *they appeared to be strictly fossil and to have been swept thither by floods, with the other animal bones, at the period of the formation of the alluvial bed itself.* If this view be confirmed, says our author, it will render probable the supposition that the human bones found in calcareous tufa are likewise referable to the same period, and *consequently that man existed here previous to the formation of the alluvial beds, the last great revolution to which the earth has been subjected.*

In the *Nachtrage* to the same work published in 1822, Schlotheim describes further researches in the same place, and speaking of the human bones which were in his collection from there, he says: "They betray a great antiquity, although they have not all undergone a change in an equal manner. Some of them have lost their animal gluten and are even penetrated with gypsum, as is the case with a considerable portion of the other animal bones, while others are only slightly calcined and decomposed. This varying condition of the bones is likewise observable in all the fossil bones of Köstritz."

Schlotheim tells us further that some human bones in his collection were found 26 feet below the surface, and underneath two phalanges of a rhinoceros, quite fossilized, which lay 8 feet above them,[1] and he urges that it is quite evident that in the country near Köstritz human bones are found intermingled, without order, with the bones

[1] These bones, according to a statement by Mr. Carter Blake, are now or ought to be in the British Museum. However this may be, I am safe in stating that there is a fine series of Gailenreuth and Scharzfeldt cave-remains in the Geological Department of the Natural History Museum, Cromwell Road, formed by the Earl of Enniskillen and Sir Philip de Malpas Grey Egerton in the early part of the last century.

of animals of the ancient world and with those of existing species, and under precisely the same circumstances, being firmly enveloped and compacted in the loamy deposit which occupies the fissures and cavities of the bed of gypsum that occurs in that vicinity. "It is undeniable," he says, "that in Winter's gypsum quarry human bones were discovered at the depth of 26 feet from the surface, lying 8 feet below the bones of the rhinoceros also there deposited. The human bones, like those of the other animals, are more or less altered, and deprived of their animal gluten. Human bones and skeletons have also been found in other places within the tract of the alluvial formations, in the vicinity of the repositories of large land animals of the ancient world, but which have not hitherto received that attention which they deserve. All these conclusions give, on the first view, probability to the conclusion that the other animals were destroyed at the same time as man, and, consequently, that the latter was already in existence in this country at the period of the destruction of the large animals; an opinion which I have already advanced."

This is all very plain, very explicit and precise, and represents the view now universally accepted, and Schlotheim ought to be considered as its first scientific champion. He would perhaps have been so regarded had he not been dominated by *a priori* views, which were then natural, and which made him suggest as *a possibility* that the human bones may have been brought thither by floods at a later time than the animal bones, and this in the face of the fact that the deposits in these caves of Gailenreuth were cased in with stalagmite and did not contain secondary burials. He therefore adopts a position of hesitation. He concludes, however, with the words: "So much, however, appears to be proved, that they [i.e. the human bones] occur here in a fossil state, having been brought hither by great floods at very remote times."

The memoir by Schlotheim came into the hands of Mr. Thomas Weaver, who in 1823 published a translation of it with notes in the *Annals of Philosophy*, vol. xxi, § 17. In these notes Weaver argues very acutely against the bones of men and those of the ancient animals at Gailenreuth having been deposited at different times, and claims that they were all laid down together by the same diluvial movement, and were therefore contemporary. He also shows that Schlotheim's doubts as to the contemporaneity of the ancient and more recent animals whose bones were found together, are answered by the fact that Buckland found precisely the same varying conditions in the bones from Kirkdale Cave. This shows that both in Germany and in England very sane and sound views on the antiquity of man, views which are now general, had been championed on perfectly scientific grounds as early as 1823. The position would then probably have been finally won had it not been for the authority of Cuvier and Buckland, who were strongly prejudiced against the view that man was contemporary with the extinct beasts. The former was against the occurrence even of fossil monkeys. In 1823 a very distinguished and competent

Austrian geologist, Ami Boué, discovered some bones comprising half a skeleton, but no skull, in the loess at the little town of Lahr, two German miles from the Rhine, almost opposite Strasburg in Baden. Speaking of the loess there and of this discovery, we are told: "Ce dépôt renferme des os d'espèces perdues, et c'est lui qu'une fouille avait entamé. Des ossements étaient placés à différentes hauteurs et dans des lieux où rien n'indique qu'il y ait eu jadis un cimetière. D'ailleurs les os étaient tellement engagés dans la roche qu'il fallut prendre assez de peine pour les dégager; l'auteur fut obligé d'en laisser qui étaient situés trop avant dans la marne, tandis que cette dernière ne paraissait nullement avoir été remaniée et offrait en outre quelques coquilles terrestres d'eau douce." (Matériaux, etc., xviii, 29, 30.)

Boué, who was convinced that human bones could not exist under such conditions, and thought they must belong to some animal like man, sent the bones to Cuvier, and was greatly surprised when Cuvier pronounced them to be human. In 1829 M. Boué revisited the place where he had made his discovery, and confirmed his former observations, but in view of Cuvier's determined scepticism he suggested the possibility that, although the bones had not been artificially buried by man, they might have been washed to the place where they occurred, together with their matrix, in some exceptional flood of the Schutter or Rhine. In reporting these facts he further mentions that Count Razumofski had discovered some human skulls mixed with the remains of extinct animals in the deposit covering the Magnesian Limestone near Baden in Lower Austria. This last discovery has a more important meaning, of course, than it had in 1829, when the antiquity of man was still in question (see Ann. Sci. Nat., vol. xviii, partie Bibliographique, 150, 151).[1]

Lyell tells us that the collection of Lahr bones found by Boué was left in Cuvier's care, and having been neglected was lost ("Antiquity of Man," 4th ed., 244). Boué maintained his views in spite of Cuvier's scepticism, and many years afterwards, namely, in 1852, communicated to the Berlin Academy a short paper embodying his previous researches, in which he reiterates that the bones had not been artificially buried, and says: "*Ich noch jetzt damals glauben muss dass diesen Knochen wie die Schnecken-Gehäuse gleichzeitig mit dem mergeligen Löss-Gebilde und selbst in seinen untern Schichten abgesetzt wurden*" (Sitzberichte, vol. viii, p. 89).

In the same year that Boué made his discovery, i.e. in 1823, Professor Crahay read a paper before the Maestricht Academy on a human lower jaw still preserved at Leyden, which was found 19 feet below the surface, where the loess joins the gravel and is overlain by intact and undisturbed pebbly and sandy beds. Large numbers of remains of extinct animals were found apparently at the

[1] In my previous paper I carelessly gave a wrong reference for these facts, about which my friend Professor Rupert Jones is rightly sarcastic, and which I have now corrected. The reference is, however, a difficult one, and the "partie Bibliographique" was published separately, and has a distinct pagination.

same horizon, some of the Mammoths' remains being at a higher level. M. Crahay's paper was first published in 1836 in the Bull. de l'Acad. Royale de Belgique, vol. iii, p. 43. Lyell, who verified the facts, regarded this as one of the first examples of the occurrence of remains of man and extinct animals in a Pleistocene alluvial deposit in the open plains ("Antiquity of Man," p. 241).

Let us now turn to England. On the subject of caves and their contents Buckland's opinion dominated Englishmen just as Cuvier's dominated the Continent, and naturally, for he had had great experience in excavating caverns. He took the same side as Cuvier in regard to the introduction of remains of man into the caves having been later than those of the extinct animals. In his "Reliquiæ Diluvianæ," 1824, he mentions the discovery of human bones encrusted with stalactite in a cave in the Mountain Limestone at Burrington in the Mendips, mentioned in Collinson's History of Somerset. The mouth of the cave was nearly closed by stalactite, and many of the bones were encrusted with it. In the case of the skull the inside as well as the outside was encrusted with it, "and I have," says Buckland, "a fragment from the inside which bears in relief casts of the channel of the veins along the interior of the skull. The state of these bones affords indications of very high antiquity." It seems from our present knowledge almost certain that these bones belonged to Palæolithic man.

Secondly. In the cave at Wookey Hole human bones were found by Mr. Miller of Bristol and examined by Buckland in 1823. He says the teeth and fragments of bone were dispersed through reddish mud and clay, and some of them were united to it by stalagmite into a firm osseous breccia. As Buckland, however, found a small piece of a sepulchral urn among the bones, it makes this case a doubtful one. A more important discovery was that made in the cave at Paviland, near Swansea. He tells us how he discovered beneath six inches of earth nearly the entire left side of a human female skeleton, the parts being in juxtaposition, and in the middle of the bones was a small quantity of a yellow substance like adipocere. The bones were all stained with a dark brick-red colour, and enveloped by a coating of ruddle. Near the skeleton were two handfuls of small shells of *Nerita littoralis*, much decayed, and in contact with the ribs were forty or fifty fragments of small ivory rods, nearly cylindrical, and varying in diameter from a quarter to three-quarters of an inch, and from one to four inches in length. Their external surface was smooth in the few which were least decayed, but the greater number had undergone the same degree of decomposition as the large fragments of Mammoths' tusks. He had previously described the discovery of two decayed Mammoths' tusks in the cave. Most of the fragments were also split transversely by recent fracture in digging them out, so that there are no means of knowing what was their original length, as none were found with both extremities intact. Many of them, again, were split longitudinally by the separation of their laminæ, which were evidently the laminæ of the large tusk, from a portion of which they had been made. The surfaces exposed by this splitting, as well as the outer circumference where it was smooth, were covered with small clusters of minute and extremely delicate dendrites; so also was the circumference of some small fragments of rings made of the same ivory, and found with the rods, being nearly of the size and shape of segments of a small teacup handle. The rings, when complete, were four or five inches in diameter. The rings, rods, and shells lay in the same red substance that enveloped the bones, and were stained superficially with it, and had evidently been buried at the same time as the woman. In another place were found three fragments of the same ivory, which had been cut into unmeaning forms by a rough-edged instrument, probably a coarse knife, the marks of which remained on all their surfaces. "One of these fragments was nearly of the shape and size of a human tongue, and its surface was smooth as if it had been applied to some use in which it became polished; its surface was also covered with dendrites like that of the rods; there was found also a rude instrument resembling a short skewer or chopstick, and made of the metacarpal bone of a wolf, sharp, and flattened to an edge at one end, and terminated at the other by the natural rounded condyle of the bone. . . . No metallic instruments have as yet been found with these remains. . . . The ivory rods and rings and tongue-shaped fragment were certainly made from the antediluvian tusks that lay in the same cave, and must have been cut from the ivory when hard and not crumbling to pieces, as it is at present on the slightest touch, whence we may assume their high antiquity."

We can hardly doubt with our present knowledge that these bones were those of a Palæolithic woman, and it seems a real pity that our famous Dean, whose acuteness was so remarkable, should have been entirely blinded by his prepossessions in favour of a quite impossible and quite unattested Biblical chronology in arguing, as he did, that the bones, etc., had been buried subsequently to the burial of the bones of the extinct beasts, for this discovery ought to have secured for England what was much later secured for Belgium by Schmerling —the honour of the settlement of one great question in the issue, the historical development of which we are tracing, namely, the contemporaneity of man and the extinct beasts.

Let us now turn to France. In a letter written on the 25th of October, 1828, on the caverns of Bize, Tournal tells that he had found in the same strata human bones and those of extinct species with the same physical and chemical features, "jouissant tous deux des mêmes caractères physiques et chimiques. Ces observations peuvent faire mettre en question l'existence de l'homme à l'état fossile." And he continues: "The generally admitted proposition, therefore, that on our actual continents there do not occur human fossil bones, must be treated as doubtful, or, at all events, is unestablished." Tournal at the same time allows that it is possible the human bones and the specimens of living species of shells found in the Bize caverns may have been carried in by subsequent currents of water, which rearranged the contents of the caves.

The human bones, he tells us, were found with pieces of pottery, living marine and land shells, and bones of extinct animals, in the same stratum of red cave earth (*Annales des Sciences Naturelles*, vol. xv, pp. 348–350). He adds another statement, which he did not, and perhaps could hardly be expected to, appreciate at its full value, that he also found in the cave earth fragments of flint with very sharp angles ("des fragments de silex pyromaque à angles très-vîfs").

On the 29th of June, 1829, M. Christol communicated to the Academy a notice of the caverns of Pondres and Souvignargues, near Sommières, explored by himself and M. Emilien Dumas. He was convinced that these caverns proved incontestably the mixing of human bones with those of extinct animals, and M. Cordier, the reporter of the paper, thought the facts of the deepest interest (id., p. 93), but the value of the observation is qualified by the fact that he claims to have found pieces of pottery at all levels in the cave. In a second communication made to the *Annales des Sciences* in 1829 (op. cit., vol. xviii, p. 247; and Bull. Sci. Nat., ch. xix, pp. 18–28), Tournal, referring to the recent researches of Christol just mentioned, says that they confirmed what he had long maintained, that man was contemporary with the extinct animals. He says that Christol had shown him human bones which he had found at a great depth in the caverns of the Gard, and that it was impossible to separate them in regard to condition from those of the lion, tiger, and the hyæna found with them; their chemical and physical condition was the same. In regard to the caverns of the Bize, he added the fresh fact that certain of the animals' bones had marks of human workmanship upon them. Tournal concludes his paper with a sentence which, as M. Cartailhac says, has the audacity of genius, considering that it was written in 1829. "La géologie," he says, "commence là ou l'archéologie s'arrête: lorsque celle-ci aura épuisé ces recherches et rencontré le voile mystérieux et impénétrable que couvre l'origine des nations, la géologie donnant un supplément à nos courtes annales, viendra réveiller l'orgueil humain, en lui montrant l'antiquité de sa race; car la géologie seul peut désormais nous donner quelques notions sur l'époque de la première apparition de l'homme sur le globe terrestre."

It is a matter of regret that the caves so diligently explored by Tournal should have had their contents disturbed and rearranged by secondary burials, and should have differed in this respect from those at Gailenreuth, where the stratum containing the extinct animals was apparently intact. The early French explorers were also not sufficiently careful in their digging to separate the different layers, nor was it known at that time that so-called Palæolithic man had not learnt the use of pottery.

These difficulties in a measure justified the scepticism of Cuvier, and led to these French discoveries and their importance being underrated, but when we have discounted the adventitious elements in them we cannot doubt that the human bones (especially those found by Tournal) were found together with the extinct ones in these caves in a way which makes it clear they were contemporary. This was the view of M. Marcel de Serres, to whom the question was remitted for examination by the French Academy, and who had the human bones analyzed, when they were found to have parted with their animal matter to as great a degree as those of the hyænas which accompanied them, to be equally brittle, and to adhere as much to the tongue, and were quite different in these respects from some bones from an ancient Gaulish cemetery with which they were compared by M. Ballard, a chemist of Montpelier.

Cuvier's authority, however, was supreme in France on these questions, and he was immovable. I quoted in the previous paper the pronouncement he made in 1830 in the last edition of his famous "Discours," reaffirming his scepticism as to man having been contemporary with the extinct animals. Two years later he died.

In concluding this first stage of the inquiry I would complete it by quoting a passage from Mortillet:—"Le grand Cuvier, le père de la paléontologie, a reconnu et proclamé que l'homme fossile n'exista pas! . . . Toujours le principe d'autorité qui vient barrer le chemin au libre examen. . . . C'est que chez Georges Cuvier, à côté du savant de premier ordre, à côté de l'homme de génie dont la France et le monde entier s'honorent, il y avait l'ardent bibliste. L'illustre professeur du Muséum, créant une science nouvelle, était doublé d'un médiocre conseiller d'état se posant en défenseur de ce qu'alors, comme à présent, on nommait l'ordre moral. Mais que pèse et que doit peser le sentiment intéressé de Cuvier devant la voix suprème de faits bien constatés." ("Le Préhistorique," pp. 10–11.)

The death of Cuvier did not stop the inquiries into the early existence of man, which now took a more definite shape and were especially pressed home by Schmerling. In 1833 Schmerling published his famous "Recherches sur les ossemens fossiles découverts dans les cavernes de la province de Liége." In this work he seems to me to have established beyond all possible doubt the contemporaneousness of man and the extinct animals, and he contests the *à priori* prejudice of De Luc and Cuvier, who denied the existence of fossil human bones. In regard to the main question he writes—and it would be impossible to write more wisely:—"We admit that we are completely ignorant of the precise period when man first appeared on the earth. History seems here to abandon us, and we are lost in the obscurities of mythology and of different cosmogonies; but if antiquity has left us no positive documents on the subject, it yet informs us of a certain intellectual progress in our race. No one doubts that men were once in a state of ignorance in which they approached the brute creation, only caring for the supply of their immediate wants. History only gives us vague, uncertain, and even contradictory notions on the origin of the early peoples, but it seems impossible to doubt that man was the witness of the terrible revolutions which succeeded each other before historic times. . . . It is in the great book of Nature that we ought to search for light when history gives us only vague and uncertain information." Turning then to his own researches, he says that what they put beyond doubt is, that human bones were buried at the same period and by the same cause as those of the extinct animals. He then goes on to describe in detail the human remains, comprising those of three individuals, which he had found in the cave of Engis, and which, he said, were surrounded by those of the elephant, the rhinoceros, and of extinct carnivores. He also describes a larger number of human bones found in the adjoining cave of Engihoul, where they were covered by stalagmite. These bones, he says, agree in colour, in the degree of decomposition, and in the way they occur with those of the extinct beasts; all the bones of the extremities were broken, as in the case of the other animals, and the stalagmite had penetrated into and covered the fractured faces with a deposit. He concludes the detailed account of the bones with the words: "J'ai fini par conclure que ces restes humains ont été enfouis dans ces cavernes à la même époque, et conséquent par les mêmes causes qui y ont entrainé une masse d'ossemens de différentes espèces éteintes. . . . L'homme, sans contredit, existait avant le dernier bouleversement de notre planète."

In a later chapter, in his second volume, published in 1834, Schmerling describes how, in an exploration subsequent to those described in his first volume, he had found certain objects fashioned by human hands. Thus, in the cave of Chokier he found among a number of rhinoceros teeth a triangular piece of bone cut from another which was artificially pierced, roughly tooled, and polished. Another piece of bone found in the Engis cave was pointed; it was partially covered with stalagmite. In the cavern of the Fond de Forêt he found some pieces of worked bone and horn. These he figures, as he does certain flint fragments, of which he says: "La forme régulière a frappé, au premier abord, mon attention. Dans toutes les cavernes de notre province où j'ai trouvé des ossemens fossiles en abondance, j'ai aussi rencontré une quantité, plus ou moins considérable, de ces silex." In regard to these flints he says—and mark, this was printed in 1834:—"Ces silex sont d'une longueur et d'une largeur variables; ils ont une face plane et une triangulaire, les faces étant à-peu-près de même dimension; les bords externes sont très tranchans, mais les extrémités sont obtuses. Ce que prouve que ces silex ont été longtemps exposés aux influences atmosphériques avant d'avoir été enfouis dans les cavernes, c'est qu'ils sont tous couverts d'une croûte blanchâtre qui, dans quelques-uns que j'ai brisés, ne dépasse pas l'épaisseur d'une ligne, tandis que le centre est d'un gris bleuâtre. La forme de ces silex est tellement régulière qu'il est impossible de les confondre avec ceux que l'on rencontre dans la craie et dans le terrain tertiaire. Toute reflexion faite, il faut admettre que ces silex ont été taillés par la main de l'homme, et qu'ils ont pu servir pour faire des fleches ou des couteaux. . . . Le gîte de ces os et de ces silex n'avait pas laissé matière à quelque doute, c'est à dire que un accident quelconque avait put amener ces pièces dans les cavernes après leur remplissage. . . . J'ose garantie qu'aucune de ces pièces n'a été introduite après coup. . . . Si enfin, comme en Allemagne et en France, plusieurs de ces cavernes eussent été connues depuis longtemps, et eussent servis à l'époque du moyen âge, sort de refuge ou de cimetière, certes nous aurions eu tort d'attacher la moindre importance aux débris que nous avons trouvés; mais nous répétons que, tout ce que nous avons dit sur les ossemens humains, est exact et sans réplique. Le temps seul, au reste, décidera jusqu'à quel point nous avons eu raison de nous exprimer d'une manière aussi catégorique, et aucun géologue éclairé ne voudrait soutenir aujourd'hui que l'homme n'existait point à l'époque où nos cavernes ont été comblées du limon et des fossiles qu'elles recélent." This is plain and definite, and it is the view now held everywhere. Unfortunately his own generation were deaf to Schmerling's appeals.

In the supplementary notes to his Bridgewater treatise, published in 1837, Buckland tells us that in September, 1835, he had seen the extensive collection of fossil bones made by M. Schmerling in the caverns of the neighbourhood of Liége. He says:—"The human bones found in these caves are in a state of less decay than those of the extinct species of beasts; they are accompanied by rude flint knives and other instruments of flint and bone, and are probably derived from uncivilized tribes that inhabited the caves. Some of the human bones may also be the remains of individuals who, in more recent times, have been buried in such convenient repositories. M. Schmerling, in his 'Recherches sur les Ossemens Fossiles des Cavernes de Liége,' expresses his opinion that these human bones are coeval with those of the quadrupeds, of extinct species, found with them; an opinion from which the author, after a careful examination of M. Schmerling's collection, entirely dissents." (Op. cit., p. 602.)

In the third edition of his "Principles of Geology," Lyell merely mentions Schmerling's discoveries and the latter's claim that he had found human remains with those of extinct animals, but expresses no opinion on them. This was after he had paid a visit to Schmerling in 1833. Lyell confesses that he expressed incredulity to his host about the alleged antiquity of the fossil bones in his "Antiquity of Man"; he frankly avows that in the third and subsequent editions of his famous "Principles" he had failed to give Schmerling's discoveries the weight to which they were entitled, and adds—"He [i.e. Schmerling] had accumulated ample evidence to prove that man had been introduced into the earth at an earlier period than geologists were then willing to believe," and he goes on to excuse and apologize, like the brave honest person he was, for what he had done. The words are worth quoting. "To have undertaken," he says, "in 1832, with a view of testing its truth [i.e. the truth of the discovery], to follow the Belgian philosopher through every stage of his observations and proofs, would have been no easy task even for one well skilled in geology and osteology. To be let down, as Schmerling was day after day, by a rope tied to a tree, so as to slide to the first opening of the Engis cave, where the best preserved human skulls were found; and, after thus gaining access to the first subterranean gallery, to creep on all fours through a contracted passage to larger chambers, there to superintend by torchlight, week after week and year after year, the workmen who were breaking through the stalagmitic crust, as hard as marble, in order to remove piece by piece the underlying bone-breccia, nearly as hard; to stand for hours with one's feet in the mud, and with water dripping from the roof on one's head, in order to mark the position and guard against the loss of each single bone of a skeleton; and at length, after finding leisure, strength, and courage for all these operations, to look forward as the fruits of one's labour, to the publication of unwelcome intelligence, opposed to the prepossessions of the scientific as well as of the unscientific public;—when these circumstances are taken into account, we need scarcely wonder, not only that a passing traveller failed to stop and scrutinize the evidence, but that a quarter of a century should have elapsed before even the neighbouring professors of the University of Liége came forth to vindicate the truthfulness of their indefatigable and clear-sighted countryman." That is a handsome reparation, but it came long after Schmerling had gone away to other hunting-grounds. He died in 1836, a poor and disappointed man. Let us all take our hats off to him!

IV.—Further Note on the Westleton Beds.[1]

By Horace B. Woodward, F.R.S.

THE view expressed in 1882 that the Westleton Beds of Westleton, in Suffolk, form part of the Middle Glacial division of S. V. Wood, jun., was strengthened by observations made at Southwold in 1895, and is supported by sections examined last year near Lowestoft.[2]

In Prestwich's original description of the "Westleton Sands and Shingle," he remarked that "they attain a thickness of from 30 to 40 feet, and consist of a series of stratified beds of well-rounded flint-pebbles imbedded in white sand, and with two or three subordinate beds of light-coloured clay."[3] These are the true Westleton Beds, which are exposed in pits on Westleton Moor or Common, and which extend across Westleton Heath to the cliff at Dunwich, where they rest on the Crag Series and are overlain by Chalky Boulder-clay.

In his later paper on the Westleton Beds, Prestwich took into the group a greater thickness of strata at Westleton, his "General Section" including 20 feet of "white sand passing down into ochreous pebbly sands with a few large unworn blocks of flint and some ironstone bands and concretions," which occurred below the mass of the Westleton Beds, so clearly described in his preceding statement.[4] Altogether he took in about 54 feet of strata, and although he mentioned that no fossils were met with in this

[1] Read before the British Association, Section C (Geology), Glasgow, Sept., 1901.
[2] Geol. Mag., Dec. II, Vol. IX, p. 452; Dec. IV, Vol. III, p. 357.
[3] Quart. Journ. Geol. Soc., 1871, vol. xxvii, p. 461.
[4] Ibid., 1890, vol. xlvi, p. 96.

"General Section on Westleton Common," yet in another pit on the Common he found "in digging a few feet lower, a sandy clay with very friable specimens of *Tellina* and *Natica*."

There can be little doubt that in this "General Section" the lower white and ochreous pebbly sands belong to the Crag Series, upon which as at Dunwich the Westleton Beds directly rest; and that this Pliocene formation, as Mr. Whitaker has shown, occupies a large area and forms a great portion of the Dunwich cliff.[1]

In my opinion Prestwich's original section (though diagrammatic) expresses the facts better than do his later statements. Therein the Westleton Shingle at Dunwich, that directly underlies the Boulder-clay, was rightly placed by him in the Middle Glacial ("Boulder Sands and Gravels"), while he grouped the beds at the base of the cliff, which are well known to be Crag, with the mass of the pebble-beds of Southwold. With this latter correlation also I entirely agree; both belong to the Crag Series, though Prestwich grouped both as Westleton sands and shingle. Thus troubles arose from the correlation of the Southwold shingle with that at Westleton, and they have been complicated by the inclusion of part of the Crag Series at Westleton with the Westleton Beds.[2]

Mr. C. Reid has pointed out that the shelly exposures which have been noted in the Southwold pebbly gravel in the cliff north of the town, at a pit on the Lowestoft Road, and at Southwold Station, contain a fauna identical with that of the Norwich Crag.[3] As we pass on to Easton Bavent we again see a mass of similar pebbly gravel, divided by a band of Chillesford Clay which thickens northward; and the whole in my opinion belongs to the Crag Series, with the exception perhaps of a thin gravelly covering here and there. These beds are not to be compared with the 30 or 40 feet of Westleton Beds at Westleton. As Mr. A. E. Salter has remarked, here "we have *two distinct kinds* of gravel."[4]

A section identical with that on Westleton Common is to be seen in a large pit north of the Southwold railway, where it branches off from the main line. No one would dispute that here we have the true Westleton Beds, and here they are overlain by the Chalky Boulder-clay, which was lately so well exposed in the adjacent cutting by Halesworth Station.

A glance at the Geological Survey Map shows that the separation of the pebble-beds from the Glacial sands and gravels may often be taken as a lithological rather than as a stratigraphical division, and that there is work still to be done in separating Pliocene from Glacial deposits.

There is abundant evidence to show that the buff sands which characterize the Middle Glacial Drift over large areas in East Anglia do contain bands, and here and there masses, of shingle like that of Westleton.

[1] "Geology of Southwold" (Geol. Survey), 1887.
[2] Proc. Geol. Assoc., vol. xv, p. 440.
[3] "Pliocene Deposits of Britain," p. 104.
[4] Proc. Geol. Assoc., 1896, vol. xiv, p. 398.

At Pakefield gap the Boulder-clay is well seen occupying a hollow above the Middle Glacial sand, which contains occasional seams of shingle. Further on, towards Lowestoft, near the Grand Hotel at Kirkley, the cliff shows the sands with shingle dovetailing into it, and forming the mass of the cliff to a height of 15 feet. Below the Grand Hotel a similar section, for the most part shingle, is to be seen.

Here we have conclusive evidence that the Middle Glacial sands are replaced by shingle identical in character with the Westleton Beds of Westleton. The occurrence of this pebble-bed in the Middle Glacial sand was noted by J. H. Blake, but its significance was not pointed out.[1]

Again, a large gravel-pit east of Oulton Broad (formerly Mutford) Station shows about 40 feet of white and buff sands passing down into a mass of shingle, with the sand dovetailing into it as in the cliff at Kirkley.

In the country to the north, between Lowestoft and Loddon, Reedham and Gorleston, there are other sections, as at Thorpe-next-Haddiscoe, which furnish similar evidence.[2]

In this region we are also brought into contact with a newer pebbly gravel, which has been largely derived from the Middle Glacial shingle-beds. It is on the whole coarser and more intermixed with angular and subangular flints than the local shingle-beds of Oulton, Kirkley, Halesworth, and Westleton; but very different from the boulder or 'cannon-shot' gravel of Mousehold, near Norwich. It, however, forms a portion of the "plateau gravel, sand, and loam" mapped and described by J. H. Blake as newer than the Chalky Boulder-clay.[3] It is interesting and at times perplexing. Sections along the new Yarmouth and Lowestoft direct railway north-west of Belle Vue Park, Lowestoft, and in the Oulton pit (before mentioned), show masses of this rather coarse pebbly gravel resting in places with apparent conformity, and elsewhere with marked irregularity, on the Middle Glacial sands and gravels. There would, however, be no justification in making a distinction were it not the fact that the coarser gravel does extend over the Chalky Boulder-clay, as may be observed in a large sand-pit east of Burton Cottages on the western side of Lowestoft.

Above Normanston, at the brickworks along Woods Loke, west of St. Margaret's Church, Lowestoft, the Boulder-clay is overlain by a bed of brown laminated carbonaceous loam, somewhat disturbed in places, and with pockets of sand and gravel. The loamy bed may perhaps be compared with the lacustrine bed at South Elmham described by Mr. C. Candler;[4] at any rate, it appears to mark a stage prior to the accumulation of the Plateau gravel, which rests irregularly on any of the older drifts.

[1] "Geology of Yarmouth and Lowestoft" (Geol. Survey), 1890, p. 38.

[2] Geol. Mag., 1882, p. 455; see also J. H. Blake, Geol. Yarmouth and Lowestoft, pp. 43, 44, etc.

[3] Geol. Yarmouth and Lowestoft, pp. 5, 44, 57, 61.

[4] Quart. Journ. Geol. Soc., vol. xlv, p. 504.

In this region of East Anglia we have evidence of pebbly gravels in the Crag Series, in the Middle Glacial (Westleton Beds), and in the Plateau Drift.

Where one gravel is largely derived from another and is welded on to it, there must often be difficulty in fixing a plane of demarcation, as there would be (in the absence of fossils) in separating other strata of identical lithological character.

Similar occurrences, observed in Egypt by Mr. H. J. L. Beadnell, where Cretaceous and Eocene clays appear to merge together, though not in uninterrupted sequence, have been aptly referred to by him as "*unconformable passage-beds.*" [1] The term is at any rate a useful one to bear in mind in connection with gravels, ancient and modern.

V.—The Petrographical Characters of the Darjíling Gneiss.

By John Parkinson, F.G.S.

Well known as Darjíling is to nearly every stray traveller in India, the solid geology of the district has been left almost (I believe quite) untouched since the publication of Mallet's paper [2] in 1874. There the Darjíling gneiss was described as the metamorphosed representative of the sedimentary Gondwana rocks of the south, and has so remained, albeit under protest, for a disclaiming paragraph [3] appears in the Manual of the Geology of India. In the report of the Committee [4] on the recent landslip at Darjíling it is stated that the rock of the country consists of "a well foliated and banded biotite gneiss with occasional lenses and deformed veins of granitic rock"; moreover, that "the foliation planes are often highly contorted"; and Mallet defines it as true gneiss "passing into mica schist or an intermediate variety." These descriptions are meagre, and it is hoped that the following notes on specimens collected by the author may not be superfluous.

Description.

The gneiss outcropping near the Jelapahar Road, on the eastern side of the ridge on which Darjíling stands, is a streaky or roughly banded, rather massive rock, the planes of greatest fissility glittering with black mica and containing a few pink garnets the size of a small pea. In a thin section (Fig. 1) the mica is the most conspicuous mineral. It is a dark green to reddish brown for vibrations parallel to the basal plane, and of a deep straw colour for those at right angles. The irregularly shaped garnets are very pale pink in colour, cracked, and rather dirty. The colourless constituents slightly predominate, and consist largely of quartz with orthoclase and plagioclase; some crystals of the former felspar exhibit a microperthitic intergrowth; the latter is rare and apparently

[1] Report iii, Geol. Survey of Egypt, Cairo, 1901.

[2] Mem. Geol. Surv. Ind., 1874, vol. xi, pt. 1.

[3] Geology of India, 2nd ed., p. 76.

[4] Report of the Committee on the Landslip at Darjeeling, September, 1899; published October, 1899.

albite or oligoclase. The quartz also occurs sparingly as 'quartz vermiculé.'[1] In addition, the rock contains a few grains of zircon and some crystals of an iron oxide, probably hematite. This completes the list of constituents with the exception of a fibrous mineral seemingly derived from the mica. Loss of the characteristic colour and pleochroism precede the assumption of the fibrous appearance. It then consists of a felted mass of crystals which are of a brown colour in the aggregate by an ordinary light and exhibit a rather vivid polarization. Finally, the brown colour is entirely lost and the constituent crystals fray out in a brush-like way. The mineral is no doubt sillimanite, and the thin section as a whole forcibly recalls some of the fibrolite and cordierite gneisses of Germany. The Darjíling rock is therefore a garnetiferous sillimanite gneiss, in which the presence of cordierite is to be suspected. This mineral no doubt does occur, but the rock has suffered slightly from pressure and the felspars are usually fresh and unaltered; facts not conducive to the ready determination of such a mineral as cordierite, which appears to be free from its characteristic decomposition products. The inclusion of one mineral by another is a characteristic feature; e.g., rounded 'spots' of mica are often present in the quartz, or of quartz in the felspar. The larger quartz grains are much cracked and the lines of fracture marked by infiltrated substances. A cementing of the parts has, however, always taken place.

A specimen from a roadside outcrop below Tigar Hill is a massive rock with a distinct foliation;[2] distinguished by a large quantity of silvery-brown mica, many of the flakes measuring ·15 inch across. In a thin section two micas are conspicuous—a reddish brown, recalling that of some Kinzigites, and a white. They occur closely associated, so that thin laminæ of the brown mineral are found inserted parallel or, occasionally, transversely to the basal cleavage of the white. Sillimanite is locally mixed up with films of the latter, and possibly the rock contains cordierite. Felspar is rare, and the slide contains much quartz, exhibiting very irregular outlines. Some large apatite grains (·1 inch across), considerably cracked, are also characteristic, as well as numerous small zircons. A pale yellow stain, together with the absence of a basal cleavage, in some of the white micas suggest this mineral is not always normal. A third specimen, collected near the last, shows a well-marked wrinkled structure. It contains a few irregular, but not torn, garnets, and a good deal of sillimanite associated with white filmy mica, as in the preceding slide.

The rock figured is the common type of the Darjíling gneiss, and in this bands of finer texture occur, one of which from the Rungeet Road has been sliced. Macroscopically, the constituent minerals

[1] By this term is meant the thread-like intergrowth of quartz in felspar. The branching threads are grouped often in a kind of bunch, not uncommonly radiating from a point. In the examples I have met with I believe it to be an original structure.

[2] This rock differs in appearance from the others that I collected. The specimen is browner in colour, the flakes of mica more conspicuous, and the foliation less marked.

are only just discernible to the naked eye, and the presence of mica gives it a uniform grey tint. Part of the specimen is a much coarser compound of quartz and rather decomposed felspar, with but a few flakes of mica, and containing a band, ·1 to ·15 inch thick, consisting almost entirely of the last-named mineral. The thin section shows the part of finer grain to consist of the following constituents, the whole rather crushed: brown mica which is plentiful, some white mica in part secondary, zircon fairly common, garnet rare, quartz the most abundant mineral, orthoclase and plagioclase. The felspars are commoner in some parts of the slide than in others. The plagioclase, which appears to be albite or oligoclase, is often rather unusually translucent. The quartz forms large irregular grains, and occasionally occurs as quartz vermiculé. The orthoclase frequently contains a microperthite intergrowth. Sillimanite is found in another specimen from the same locality.

Fig. 1.—Usual type of the Darjíling gneiss, × 20. An irregular crystal of garnet appears on the left side towards the top of the stage. Near it are crystals of white mica (*m.w.*). The centre of the field is occupied by brown mica (*m.b.*); basal sections are cross-hatched. Sillimanite (*sl.*) is seen on the left side. The rest of the section is composed of orthoclase (*of.*), quartz (*q.*), and a single grain of sphene (*s.*).

Amongst a pile of trimmed blocks by the roadside, I found one with a hard nodule-like 'eye' some six inches across, surrounded by the ordinary gneiss. The whole of the periphery was not seen, but the mica folia of the gneiss appeared to bend round it. Fracture, texture, and composition distinguish this inclusion from the ordinary rock. It is hard and compact with no conspicuous foliation, and breaks with almost equal ease in any direction. It has a rather dirty grey appearance from the presence of black specks of mica, ·007 inch and under in length, and it is faintly mottled by pinkish patches consisting of clusters of garnet grains, each group being roughly ·1 inch across. Under the microscope two principal constituents appear in addition to the garnet, viz. quartz and felspar. The latter forms an allotriomorphic network, indented and embayed by large quartz crystals and honeycombed by a pegmatitic intergrowth of the same mineral. A large grain adjacent to a felspar does not as a rule send offshoots into it. Only small groups of the quartz granules polarize together, though we find exceptions. Nearly one-half of the felspar shows no twinning, and the remainder, judging by the extinction measured parallel to the trace of the plane of twinning, is much more basic than might be supposed, symmetrical angles ranging from 35° to 40°. The larger quartz grains exhibit rows of inclusions parallel the one to the other. The garnets are a pale claret-red, subangular in outline, and occasionally making an attempt at idiomorphism, and rather cleaner than those of the gneiss. Grains of zircon and sphene are not uncommon. Flakes of brown mica are scattered sparingly and rather irregularly across the slide.

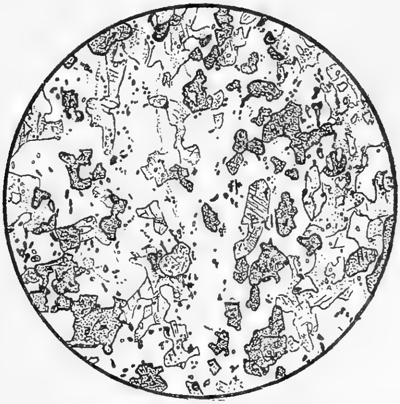

Fig. 2.—Nodule-like inclusion, × 20. Near the centre of the stage, or slightly below it, the following letters are placed to indicate the various constituents: *gt.* garnet, *p.* plagioclase (faintly dotted), *gr.* graphite, *q.* quartz (colourless), *i.* ? idocrase, *s.* sphene. The small colourless microlites mentioned in the text are also indicated.

Passing away from the centre of this 'eye' towards the surrounding gneiss, we find that this hard and compact rock graduates into one of slightly granular texture, rather whiter and containing larger flakes of brown mica and less clear garnet spots. A thin section cut near the junction shows the latter mineral associated with some good-sized crystals of sphene.[1]

On the western side of the ridge the same general characters are repeated. Thus, on the road from Darjíling to Ghoom, a common type of the gneiss contains numerous streaks or elongated lenticles of quartz and felspar, arranged usually in an undulating manner and occasionally retort-shaped in section. The rock weathers to a grey tint and contains characteristically a rather large quantity of mica. A hard lenticle or eye, resembling that noticed as occurring in the gneiss of the Rungeet Road, was found in this rock. The length was

[1] Occasionally ·02 inch long. The slide contains a little augite.

about 9 inches, the thickness 2·5 inches. The specimen was rather darker in colour than that above described, with a siliceous aspect, and faintly mottled with red garnets (Fig. 2). The quartz grains are subangular in outline, occasionally exhibiting crush shadows. They contain very many small crystals of a colourless mineral in the form of prisms having lath-shaped sections, which I am unable to name. The groups of garnet grains show a distinct attempt at a general linear arrangement, and a similar elongation occurs in all the minerals. The slide contains sphene and at least two other minerals which are noteworthy. I am indebted to Canon T. G. Bonney for suggestions concerning these. First, a considerable quantity of an opaque mineral characterized by its elongated shape (commonly about ·0038 × ·00055 inches). The outlines are rather jagged and uneven, the colour by incident light is grey, and the lustre metallic. It is associated with a little specular iron, which is also met with elsewhere in the slide. In order to test the streak I powdered a small quantity of the rock, and by means of a lens isolated a few of the black flakes and pressed them with a knife blade upon a sheet of notepaper. They yielded readily to the pressure and left a dull grey mark. I concluded, accordingly, that the mineral is graphite. It occurs, though less plentifully, in slides of other nodular eyes. The second mineral usually forms small and more or less rounded grains. An idiomorphic outline is sometimes indicated by the occurrence of stumpy rectangles, (extinction takes place parallel to the sides) with unequally truncated corners. The refractive index is higher than that of apatite, to which we see a resemblance in double refraction, slightly bluish colour, roughened aspect, and absence of cleavage. A grain occasionally appears isotropic. I incline to refer the mineral, but with hesitation, to idocrase.

Another specimen from the same locality, as seen in a thin section, consists of a network of large quartz grains and very irregular plagioclase, exhibiting as before much micropegmatitic quartz. Garnets, some dozen grains of sphene, and a number of mica flakes make up the rest of the slide.

On the western side of the Darjíling ridge, near St. Joseph's College, scattered sections of the gneiss are found sufficient to enable its characters to be studied. The rock is frequently gnarled with irregular bands; once I saw such a one, rich in quartz and felspar, diminish in thickness in 3 feet from 9 inches to 2·5 inches. Close by, a broad band at least a foot across was streaked and veined irregularly by darker, i.e. by more micaceous, material. Parallel to this were others shaped like very elongated lenticles. Again, the gneiss on Birch Hill Road was occasionally beautifully puckered in successive V's; and some infiltration veins had been formed subsequently to the folding. The gneiss *in sitû* about three-quarters of a mile from Darjíling is a finely foliated, slabby rock of medium grain, containing a considerable quantity of mica. A thin section discloses the presence of sillimanite, white and brown micas, and a few irregular pinkish garnets about ·04 inch across. The very irregular grains of quartz are frequently cracked and show crush shadows. Plagioclase is not uncommon, zircon as before, and some quartz vermiculé. Possibly the rock contains cordierite.

Conclusions.

One characteristic feature of the rock, the irregular outline of the grains and the inclusion, or partial inclusion, of one mineral by another, may, in my opinion, be best explained as the result of movement in a somewhat viscous mass. The cracked quartzes and garnets, the lines of fracture in which are now healed, together with a confused grouping often found among the smaller particles of quartz and felspar, indicate that, at one time, the rock has suffered from the effects of crush, from which it subsequently, more or less completely, recovered. The outlines of the quartz and felspar, which, as just remarked, may be accounted for by fluxional movement, at the same time suggest that pressure has been at work forcing them, as it were, into the minimum space.

The presence of sillimanite and probably of cordierite, which render the alumina percentage unusually high,[1] may possibly be due to an incorporation of argillaceous material, although no obvious reason exists why the magma may not have been exceptionally rich in this constituent from the beginning. However this may be, the Darjíling gneiss is certainly not a result of the metamorphosis of Gondwana beds.

Another point requiring elucidation is the presence of the hard siliceous 'eyes.' Conceivably during the movement preceding its solidification, the magma picked up small fragments of a foreign rock, which, being softened and permeated by their liquid surroundings, have resulted in the mineral assemblage seen. The graphite must have formed, if not from igneous fusion, then from a state closely approaching it. The structure as a whole is indicative of crystallization where freedom of molecular movement was restricted.[2]

To Canon T. G. Bonney I am indebted for many valuable suggestions which are embodied in the preceding notes.

NOTICES OF MEMOIRS.

I.—Ice-Erosion in the Cuillin Hills, Skye. By Alfred Harker, M.A., F.G.S. Trans. Royal Soc. Edinburgh, 1901, vol. xl, pt. 2, pp. 221–252.

THOSE who are interested in hill-climbing will know that "Sligachan, in Skye, is the rock-climbing centre *par excellence* of the British Isles"; and as Mr. Charles Pilkington further remarks in the fascinating Badminton volume on Mountaineering, "The Alpine climber will find an additional interest in the district from

[1] See Mr. J. J. H. Teall's Pres. Address to Geol. Assoc., Proc. Geol. Assoc., 1899, vol. xvi, pp. 72, 73.

[2] See paper by Canon T. G. Bonney, Quart. Journ. Geol. Soc., 1891, vol. xlvii, p. 105.

the remarkable indications of former glaciers; in some places it would seem as if they had disappeared but a few years previously, and occasionally, whilst climbing some smoothly rounded buttress, one almost expects to see the ice itself creeping through the next depression."

More than fifty years ago J. D. Forbes drew attention to the traces of ancient glaciers in the Cuillin Hills, but it has remained for Mr. Alfred Harker to work out and portray in masterly style the somewhat complex glacial history of this mountainous region.

The Cuillins, though formed of rocks wholly younger in age than the London Clay, are better entitled to take rank as mountains than any other elevations in Britain. The main range takes a semicircular form; it is built up of a great laccolitic mass of gabbro, and its sharp and rugged peaks rise in many places above 3,000 feet. Separated from these by Glen Sligachan is a range of 'Red Hills' formed of granite and granophyre, whose smooth and dome-like elevations, mostly under 2,500 feet, appear in marked contrast both in colour and outline with their dark and grim neighbours. Those who tread the stony track-way from the Sligachan Hotel to Loch Coruisk, may feel fatigue at the end of their journey, but they cannot fail to be fascinated with the grandeur of the Glen.

Mr. Harker points out that during the period of maximum glaciation these Skye mountains sustained a small local ice-cap, round which the great Scottish ice-sheet flowed north-westwards and south-eastwards, traversing the peninsula of Sleat, the islands of Pabba and Raasay, and that portion of Skye which lies north of Portree. Both the Cuillins and the Red Hills afforded gathering-ground for the local ice, under which they came to be wholly buried, for its thickness was probably not less than 3,000 feet. This local ice and that of the Scottish sheet were in equilibrium for a long time along their line of confluence; but the movements of the local ice are indicated by the directions of striæ on rock-surfaces, and by the distribution of boulders of local and recognizable rock-types. There is a noticeable absence of foreign boulders in central Skye, except near the shore, where they occur occasionally up to as much as 75 feet above sea-level. Along this margin, however, there are relics of the 'hundred foot' raised beach, which prove that the land stood lower by that amount at the close of the Glacial Period.

Interesting observations are made on the movement of the ice during the great glaciation, and it is pointed out that the striæ necessarily give only the direction of movement of the lower layers of the ice, and this appears to be true also in great measure of the dispersal of boulders.

The natural outward flow of the ice was in general closely guided, as regards its lower layers, by the form of the ground, but as the land for many miles from the Cuillins was wholly buried in ice, the form of the ground exerted only a partial control over the direction of flow. Thus it is not improbable that the upper layers followed in places a somewhat different course from that proved with regard to the lower layers.

The author points out that while the carving out of the main features of mountain and valley was due to aqueous erosion in pre-Glacial times, the actual details of the relief are due to the action of ice and frost during the Great Ice Age. Before glaciation the drainage system was a fully established one, and erosion was practically at a standstill, as it is under present conditions.[1] Hence the effects of ice and frost action remain practically without modification by later agencies; and almost every square foot of the surface bears the stamp of glaciation. It is clear, as the author remarks, that the ice has been in close contact, throughout its whole extent, with the subjacent rocks, and has forced its way into hollows and openings, vertically and horizontally, in a fashion which argues effective plasticity in its lower layers.

He points out that it is practicable to distinguish the features due to glacial from those due to aqueous erosion. The work of the ice was something more than a mere excoriation of the surface, and in comparing the work of ice and of water he observes that "a sand-grain gripped in the sole of a glacier, or of an ice-sheet thousands of feet in thickness, must be incomparably more efficient as a graving tool than the same grain rolled along the bed of a stream." Ice-action, then, must be rapid compared with that of running water; its work is done, moreover, with little or no chemical co-operation, and instead of the relief produced by ordinary weathering agents, features are carved out of the rock-complex in a fashion wholly irrespective of lithological differences or geological structure. Lateral erosion, too, comes in unfettered by any consideration of 'base-level,' and valleys may be widened as well as deepened and their sides straightened.

Attention is drawn to the formation of cirques or corries and of small rock-basins on their floors. The erosion of these was dependent upon an adequate supply of débris or abrading material at the under surface of the ice, and as the excavation of the higher cirques proceeded the dividing ridges became intensified. On the principal ridges, which acted as ice-sheds, ice-erosion necessarily failed for want of a tool to work with.

The author observes that if we take the Cuillin district as a type, it appears that ice-erosion does not, like water-erosion, work constantly towards the establishment of an even gradient along a valley in which it operates. Erosion will be most efficient when the pressure below the ice is greatest, that is, when the thickness is greatest, and differential erosion will operate so as to exaggerate inequalities. This would be arrested when the lower layers of the ice begin to be ponded in the lee of a strong feature, and the upper layers slide over them. Thus, rock-basins in valleys are dependent not merely on glacial erosion, but on glacial erosion operating under certain local conditions and in more than one way. Detailed observations and soundings made by the author and

[1] See article by A. Harker on Subaërial Erosion in the Isle of Skye: Geol. Mag., 1899, p. 485.

Mr. T. A. Falcon on Loch Coruisk, show that it occupies an area of two rock-basins, which have been excavated by ice-action.

Evidence is brought forward to show that succeeding the great glaciation there was a minor glaciation due to the action of glaciers occupying the valleys, at a time when the obstruction caused by the Scottish ice-sheet had been removed, and when the Skye ice was free to follow a course more in accordance with local topography. The author observes that the distribution of the cirques suggests a connection with the direction of sunshine; that the asymmetric character of the ridges and valleys in the outer parts of the mountain area may be attributed to the different aspects of the slopes relatively to the sun; and that therefore this influence was exerted, not at the time of maximum glaciation, but when the ice-cap had shrunk so as to occupy the valleys alone, and during the later glaciation, which was effected by glaciers only. He has not attempted in all cases to apportion the work of erosion between the ice-cap and the glaciers. His further detailed observations on the drift deposits, on the distribution of boulders, on perched blocks, and on the formation of screes will be read with profit. They furnish evidence of his careful methods of research, and of the impartial way in which on all occasions he interprets the facts.

II.—The Granite of Tulloch Burn, Ayrshire. By Professor James Geikie, F.R.S., and John S. Flett, M.A., D.Sc.[1]

THE granite of Tulloch Burn, Ayrshire, is a small mass occupying an area of three or four square miles on the headwaters of the Irvine and the Avon. Much of the outcrop is covered with drift and peat, but good exposures of the granite and the contact-altered rocks can be obtained in the Tulloch Burn, a tributary of the Irvine, and on the Avon. The prevalent type is a flesh-coloured biotite-granite, which often contains hornblende and sometimes decomposed augite. This passes at its margins into rocks of intermediate or basic composition, which include various types of diorite, hyperite, and gabbro. The evidence points to the origin of these rocks by a process of differentiation, and both in this respect and in the rock species which have been developed the resemblance to the granites of the Southern Uplands is very close. The material microscopically examined includes—Graphic Granite and Granophyric Granite (in segregation veins); Biotite Granite, Biotite Hornblende Granite, Biotite Augite Granite; Tonalite (intermediate between Hornblende Biotite Granite and Diorite); Quartz Hornblende Diorite, Quartz Augite Biotite Diorite, Quartz Hypersthene Diorite; Biotite Augite Diorite, Hornblende Diorite, Hypersthene Diorite; Hyperite and Gabbro.

This mass is intrusive into the Lower Old Red Sandstone, which at Lanfine, a little west of this, has yielded *Cephalaspis Lyelli*. The Old Red Sandstone is indurated and often hornfelsed to a varying distance from the margin. The new minerals developed are Augite,

[1] Read before the British Association, Section C (Geology), Glasgow, Sept., 1901.

Hornblende, Biotite, Magnetite, Tourmaline, Spinel, and possibly Sillimanite; Calcite, Chlorite, and Epidote are often present, but appear to be secondary after some of those mentioned.

Many dykes penetrate the sandstones, and most of these are undoubtedly apophyses of the Granite. They are mostly Diorite Porphyrites or Quartz Diorite Porphyrites, which may contain Biotite, Augite, Hornblende, or Hypersthene. Syenite Porphyries also occur, and occasionally small veins of more acid character, which may be considered coarse-grained Granophyres. In addition to these there are several dykes of Olivine Dolerite and Andesitic Basalt, but these are not known to be genetically connected with the Granite.

III.—Notes on the occurrence of Phosphatic Nodules and Phosphate-bearing Rock in the Upper Carboniferous Limestone (Yoredale) Series of the West Riding of Yorkshire and Westmoreland Border. By John Rhodes, of the Geological Survey.[1]

By kind permission of the British Association Committee on Carboniferous Zones I am enabled to announce the discovery of phosphatic nodules and of a rock having a phosphatic matrix in the Yoredale rocks of the following localities:—

Phosphatic Nodules: Far Cote Gill, East Slope of Swarth Fell, Westmoreland.

These nodules occur along with ironstone septaria in blue shales which rest on the top siliceous beds of the Underset Limestone. The nodules are confined to the lower 5 feet of the shales, and are more numerous in the lower half than in the upper half.

In the same gill, and resting on the chert of the Little Limestone, there is a layer, 3 inches in thickness, containing phosphatic nodules embedded in a fine clayey matrix. It is sprinkled throughout with glauconite grains and angular chips of quartz, and is overlain by ironstone shales.

At the same horizon as above, but $2\frac{1}{4}$ miles to the south-east, there occurs in a gill that runs from Lambfold Crags to Lunds Church, two miles west of north of Hawes Junction, a layer of rock three inches in thickness, with a phosphatic matrix throughout. This layer, which has a crust of brown iron-ore, is rich in glauconite and quartz grains, and also contains fragments of conodonts, etc.

Phosphatic Nodules: Goodham Gill, East Slope of Swarth Fell, 2 miles north-west of Hawes Junction, Yorkshire.

The phosphatic nodules at this locality occur throughout a limestone which varies in thickness from 3 to 6 inches. This layer is underlain and overlain by shale in more or less rotten condition. The horizon is doubtful, but it appears to be about 170 feet over the Little Limestone. From the upper surface of the top bed of the Crow Limestone, Cartmere Gill, East Baugh Fell, Grisdale,

[1] Read before the British Association, Section C (Geology), Glasgow, Sept., 1901.

$2\frac{1}{2}$ miles west-north-west of Hawes Junction, I have obtained a solitary example of a phosphatic nodule. The phosphatic nodules and phosphatic matrix examined show sponge spicules, but these are for the most part fragmentary; some are of crypto-crystalline silica, some replaced by calcite, whilst the axial canals are often filled with the same phosphatic material as the matrix. The spicules are referred to hexactinellid and to monactinellid sponges.

I am very much indebted to Dr. G. J. Hinde for notes on the sponge remains, and also to Dr. W. Pollard for testing the phosphates.

IV.—Short Notices.—In Sprawozdanie Komisyi fizyograficznej, Cracow, vol. xxxvi, pp. 11, 12, Professor J. L. M. Lomnicki describes a new species of *Elater*, *E. Wisniowskii*, based on a right elytra found between fossil leaves in Miocene clay near Kolomea. The elytra most nearly resembles that of *Elater ferrugatus*, a species now living in the same European region. It is the oldest fossil insect as yet found in Galicia, those described by A. M. Lomnicki, the Professor's father, being of Pleistocene age. The paper is written in Latin, and illustrated by three text-figures.

Bolivian Fossils and Rocks.—In Sir Martin Conway's "The Bolivian Andes" (Harper, 1901) will be found appendices by R. B. Newton on some Devonian Brachiopoda and incertæ sedis, by L. J. Spencer on Bolivian minerals, and by T. G. Bonney on rock specimens collected during the expedition. The author refrains from acknowledging his indebtedness to these writers on his title-page, and as he does not trouble to write a preface to his volume the papers are likely to be overlooked.

REVIEWS.

The Geological Survey of the United Kingdom.

The Summary of Progress of this institution for 1900 has just been issued, somewhat tardily if we may judge by Sir Archibald Geikie's preface, the date of which (February 28th) coincides with the termination of his long period of public service.

A considerable portion of the volume before us is taken up with a description of the structure and mineral characters of the Highland schists. Reference is made to the mapping of certain "Green beds," which in the area north of the Tay are represented by fine hornblendic schists, usually containing small garnets; and to the characters by which these altered sedimentary rocks can be distinguished from the epidiorites.

In Ireland the volcanic rocks in the Silurian series have received much attention; while in Cornwall and Devon the subdivision of the "Killas," the correlation of the Lower Devonian rocks near Looe, and the various "greenstones" have occupied those engaged in the field.

The Old Red Sandstone has been studied in various localities from Caithness to South Wales. Especially interesting are the observations on the newer granites of the Southern Highlands and their connection with the Lorne volcanic region, where the volcanic vents are of Lower Old Red Sandstone age. The granites are those of Ben Cruachan, Blackmount, and the Moor of Rannoch.

Work has been carried on in the Coalfields of South Wales and North Staffordshire. Attention has been recalled to the Gower Series near Swansea, Lower Carboniferous strata which lie above the massive Carboniferous Limestone. They had been compared with the Coddon Hill Beds of North Devon by De la Beche, and recent investigation has confirmed the correlation. Moreover, Radiolaria have been identified in the South Wales chert by Dr. G. J. Hinde. A somewhat similar group of strata has been observed along the northern side of the Coal-basin in Carmarthenshire.

Some of the detailed results of the Survey work in the Coal-measures near Swansea are given, and attention is drawn to the positions of the principal seams of coal and to the faults and disturbances by which they are affected.

Comparisons are made between the succession of Coal-measures in North Staffordshire and that in Denbighshire, the stratigraphical divisions being found to be so nearly identical that evidently the same conditions were prevalent in both districts at the close of the Carboniferous Period. A very similar succession, moreover, can be made out on the northern flanks of the Clent Hills between St. Kenelms and Old Hill.

There are notes on the granite of Cornwall, and evidence is given for concluding that not only is there a close connection between the major joints and the grain of the rock, but that this grain is dependent on the internal mineral arrangement of the granite, all three phenomena being closely related. This is noticed in the orientation of the felspars, of which the long axes lie parallel to the cleaving-way joints.

There are short accounts of Triassic and Jurassic strata in the midland counties of England and in Skye. More attention is given to Cretaceous rocks, and comparisons are made between the divisions of the Lower Greensand in West Sussex and in the Isle of Wight. The occurrence of masses of white limestone and chert with Chalk fossils, in a large volcanic vent in the Isle of Arran, is recorded, and further particulars are given of the interesting discovery therein of fragmentary portions of Rhætic and Liassic strata. These researches have not only thrown new light on the former extension of the Secondary strata over the south of Scotland, but they also afford evidence of the Tertiary age of the great series of younger igneous rocks in Arran.

Further information is given on the Tertiary volcanic series in Skye and on dykes in Western Argyllshire.

Reference is made to the overlap of the Bagshot Beds on to the Chalk in the western part of the Hampshire Basin, and attention is called also to the overlap of the London Clay, which in places cuts through the Reading Beds and rests on Chalk. The occurrence is noted of small quantities of nickel and cobalt in the Reading Beds at Cadmore End Common, near High Wycombe.

The Pleistocene deposits, including Glacial drifts, are described in various districts in the southern and midland counties of England, in South Wales, in the Highlands of Scotland, in Skye, and Caithness. Especially interesting is the account of the high-level and other drifts near Macclesfield in Cheshire. The more recent deposits have also received attention. In the petrographical work we note a special account of the remarkable assemblage of eruptive rocks which has been detected in Assynt, and of the metamorphism induced by them on the surrounding dolomites. Thus it is shown that the marbles of Assynt are mainly altered dolomites.

The palæontological work has largely assisted the stratigraphical work, and aid has been given by Mr. R. Kidston in naming the Carboniferous plants of Berwickshire, and by Dr. Traquair in naming the Silurian fishes of Lesmahagow.

The important catalogue of type and figured fossils preserved in the Museum of Practical Geology, commenced in the Summary of Progress for 1899, is continued by the publication of the lists of Pleistocene, Pliocene, and Devonian specimens.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—November 20th, 1901.—J. J. H. Teall, Esq., M.A., V.P.R.S., President, in the Chair.

Dr. Vaughan Cornish, in exhibiting Photographs of Waves and Ripples in Water, Cloud, Sand, and Snow, said that he need only refer to the photographs showing the action of wind upon snow, which were the most recent of the series of pictures which he was exhibiting that evening. He had spent from December to March last Winter studying the snow in the provinces of Quebec, Manitoba, and British Columbia. When the wind blew one saw the processes of wind-erosion and of the accumulation of drifted material proceeding with a rapidity which is not attained when wind acts upon heavier or harder materials. He particularly commended to geologists the study of wind-erosion of snow hardened by pressure and low temperature. The cutting and carving, and the revelation of previously invisible stratification, went on at a surprising rate, and one could see the structures change from form to form under one's very eyes, and thus quickly gain such an insight into the processes of wind-erosion as, in the case of more stubborn rock, could only be obtained by prolonged study. The advantage, moreover, of studying the process in snow was not merely one of time, but consisted partly in the recognition of transitional stages which were so apt to be missed when observations were necessarily intermittent, as was the case with those of erosion of harder rocks.

The following communications were read :—

1. "Notes on the Genus *Lichas.*" By Frederick Richard Cowper Reed, Esq., M.A., F.G.S.

The various attempts which have been made to separate this genus into subgeneric groups have not been altogether satisfactory, owing to the difficulty of deciding what are the more important structural features. A natural classification, as opposed to an artificial one, should be based on the structural characters of the head-shield; and the variations in the form and lobation of the glabella in the Lichadidæ (as Beecher has remarked) indicate differences in the relative development of the appendages and organs of the head. The origin and application of the various proposals for classification are considered, and certain synonyms and names of prior application to other organisms are rejected. Next, the characters of the original type-species of the various subgenera are summarized. The second part of the paper contains a critical consideration of the homologies of the furrows and lobes in the glabella of the Lichadidæ. Following Beecher's scheme, the anterior lateral portion of the so-called median or frontal lobe is considered to correspond to the antennulary or true first lobe of the glabella. The so-called 'first' lateral lobes of *Lichas* would correspond to the fused antennary and mandibular lobes, the true second and third lobes of the glabella. The lateral lobes, which are usually termed the 'middle' or 'second' lateral lobes, become homologous with the fourth or first maxillary; and the neck or occipital lobe or ring falls into its right place as the second maxillary lobe. By means of this principle an attempt is made to discover the principal lines of modification along which the evolution of the head-shields of the Lichadidæ has proceeded. In the third part of the paper the Lichadidæ are divided into two great groups: (1) that with a pair of bi-composite lateral lobes to the glabella and a more or less definite fourth pair of lateral lobes; and (2) a group with a pair of tri-composite lateral lobes, through the fusion of the fourth pair with the bi-composite pair of the preceding group. Names are proposed for each group, and also, where necessary, for the eight sections, of subgeneric value, into which each group is subdivided. The paper closes with a list of the British members of the family Lichadidæ, to show their distribution among the groups and sections.

2. "Some Remarks on the Meteorological Conditions of the Pleistocene Epoch." By Dr. Nils Ekholm, Meteorologiska Central-Anstalten, Stockholm. (Communicated by Professor W. W. Watts, M.A., F.G.S.)

The opinion of the author on this subject differs in some important respects from that of Mr. Harmer. He considers the subject under two heads: (1) What are the meteorological conditions necessary and sufficient to produce a permanent ice-sheet such as that of the Great Ice Age? (2) What will be the influence of such glaciation on the meteorological conditions, especially on the cyclones and anticyclones, of the ice-covered land and on its neighbourhood? The snow-line does not correspond with the mean annual isotherm of 32°, for Verchojansk in Siberia is not glaciated, whereas the southern point of Greenland is. The former has a Winter anticyclone, while the latter is traversed by the central or northern part of cyclones during the whole year. The area of Pleistocene glaciation in America and Europe coincides with the areas now traversed by the most regularly frequented storm-tracks. There seems to have been about the same difference between the mean annual temperatures of Europe and North America in the Great Ice Age as now, and it is generally agreed that a lowering of the present snow-line by 1,000 metres would give rise to a similar Ice Age. The hypothesis that a glaciation of North America would raise the temperature of Europe, and *vice versâ,* seems to the author physically untenable. The positions and movements of anticyclones are not generally ruled by the ground temperature in our latitudes: they are in most cases eddies formed by the air-circulation in general, and in this the greater area and receipt of heat by the Equatorial regions must always be a preponderating factor. The author considers that the influence of the Glacial Period on atmospheric circulation would probably be similar to that of a cold Winter nowadays. The cyclones would be gradually deviated into a more and more southerly track, while an anticyclone would be formed in the north, not, however, a stationary one, but travelling like a cyclone, only more slowly and irregularly. The Summer must have been cold and stormy, with frequent fogs, somewhat like that of Cape Horn or Kerguelen Island at the present day. The author considers that Mr. Harmer underrates the effect of isolation and overrates that of the winds. "The temperature of the Summer only is essential for the phenomenon of glaciation."

3. "On the Origin of certain Concretions in the Lower Coal-measures." By H. B. Stocks, Esq., F.I.C., F.C.S. (Communicated by Professor W. W. Watts, M.A., F.G.S.)

In certain of the Lower Coal-measures of Lancashire and Yorkshire and in the 'hard-bed coal,' peculiar concretions known as 'coal-balls' occur, which have a considerable interest because they contain well-preserved plant-remains. The author's analysis shows that they consist mainly of calcium-carbonate and iron-pyrites, in varying proportions. Carbonate of lime appears to have been introduced by osmosis through the cell-walls; and that it was introduced in small quantity and under exceptional circumstances appears to be proved by the comparative rarity of the concretions and their presence in this seam of coal only. During the decay of the vegetable matter of which coal is formed, in contact probably also with animal matter, some of the organic matter would pass into solution in water, causing the absorption of the oxygen in solution; the result of this is that further decay would take place under anaërobic conditions. This, occurring in water containing sulphates, would give rise to sulphuretted hydrogen and mud blackened by the presence of ferrous sulphide, while carbonates would also be produced. Experiments were tried (1) on the precipitation of carbonate of lime under varying conditions (in presence of organic matter, etc.); (2) on the action of salts of lime and of iron on wood; and (3) on the action of bacteria on solutions containing calcium-sulphate in solution and ferric oxide in the deposit. In the first series carbonate of lime was deposited in spheres; in the second it was found that iron-salts are preservatives, but lime-salts are not; and in the third, black mud, largely consisting of ferrous sulphide, was produced, while the calcium-sulphate was converted into carbonate. It is considered that these experiments explain the origin of the 'coal-balls.'

II.—December 4th, 1901.—J. J. H. Teall, Esq., M.A., V.P.R.S., President, in the Chair.

Professor Bonney, in exhibiting a series of specimens of Smaragdite - Euphotide from the Saasthal, remarked that they illustrated its variations in mineral composition; the pyroxenic constituent being sometimes diallage, sometimes rather acicular hornblende, sometimes glaucophane, but generally smaragdite; the felspathic constituent passing from a rather changed felspar to the so-called saussurite; garnets are sometimes common, white mica occasional: these different kinds pass one into another. The rock also varies greatly in coarseness, and often exhibits a distinctly streaky structure. He described the locality where the rock occurs *in sitû.*

Dr. Vaughan Cornish, in exhibiting photographs of 'Snow Mushrooms' taken by him in January, 1901, at Glacier House, near the summit of the Canadian Pacific Railway in the Selkirk Mountains, west of the Rockies (British Columbia), altitude 4,000 feet, said that the snowfall had been 25 feet measured, then represented by a 5-foot layer upon the ground. It is said that there is not much wind here, and that the snow mostly falls at a temperature near the melting-point. It has the reniform habit in great perfection, and its clinging masses are very beautiful. The most remarkable thing about it is the formation of symmetrical caps, which overhang, by a yard and more, the supporting pedestal. The stumps of the felled trees usually have bases 2 to 4 feet in diameter, which support the whole depth of snow and are frequently of such a height as to produce, with the cap of snow, an almost perfect reproduction of a mushroom. Their almost perfect symmetry was attained, he believed, by gradual growth until the limit of cohesion was reached in all directions. The tree-stumps being almost exactly circular, the complete cap is also circular. These caps are very stable, the great weight of superincumbent snow welding the lower layers into a tenacious mass. Their study has, at least, a suggestive value to geologists.

The following communications were read:—

1. "On a new Genus belonging to the Leperditiadæ, from the Cambrian Shales of Malvern." By Professor Theodore Thomas Groom, M.A., D.Sc., F.G.S.

Forms referred to *Beyrichia* have long been known from the Cambrian beds of Scandinavia, Stockingford, and South Wales; and the writer has obtained from the lowest part of the Malvern Black Shales a species identical with the Stockingford form, which had been provisionally identified with the Swedish *Beyrichia Angelini.* The characters of these specimens serve to separate the species from those now placed under the genus *Beyrichia,* a conclusion in which Professor T. Rupert Jones concurs. The specimens were obtained from Black Shales at the northern extremity of Chase End Hill, associated with *Acrotreta, Agnostus, Kutorgina pusilla,* and *Protospongia fenestrata.* The shales are nowhere actually exposed, and can only be reached by excavation. The specimens are frequently crushed and indented. The new genus appears to be most nearly related to those provided with broad lobes, such as *Klœdenia, Beyrichia, Ctenobolina,* and *Tetradella.* Specimens obtained by Professor Lapworth from the Oldbury Shales below the zone of *Sphærophthalmus alatus* are also referred to the same genus and species. From Linnarsson's description of *Beyrichia Angelini* it would seem that this form may be related to the new genus, but it clearly belongs to a different species.

2. "The Sequence of the Cambrian and Associated Beds of the Malvern Hills." By Professor Theodore Thomas Groom, M.A., D.Sc., F.G.S. With an Appendix on the Brachiopoda by Charles Alfred Matley, Esq., B.Sc., F.G.S.

The series, exclusive of some 600 feet of igneous rocks, may be estimated at between 2,500 and 3,000 feet, and consists of the following members, tabulated in descending order:—

4. The Bronsil Shales, 1,000 feet thick; grey shales containing *Dictyonema* and many Tremadoc brachiopods and trilobites.
3. The White-leaved Oak Shales; black shales, including:
   (*b*) The zone of *Peltura scarabæoides, Sphærophthalmus alatus, Ctenopyge pecten, Ct. bisulcata, Agnostus trisectus*; 500 feet.
   (*a*) The zone containing *Kutorgina pusilla, Protospongia fenestrata,* a new variety of *Acrotreta,* and a new genus of the Leperditiadæ; 30 feet.
2. The Hollybush Sandstone, comprising:
   (*b*) Massive Sandstone, probably not less than 1,000 feet thick, and containing *Kutorgina Phillipsi, Orthotheca fistula, Scolecoderma antiquissima,* and new species of *Hyolithus.*
   (*a*) Flaggy and Shaly Beds, not less than 75 feet thick; chiefly flaggy and shaly glauconitic sandstones, with *Kutorgina Phillipsi, Scolecoderma antiquissima, Hyolithus,* etc.
1. The Malvern Quartzite,[1] consisting chiefly of grey quartzites and conglomerates, rarely glauconitic; probably at least several hundred feet thick; containing *Kutorgina Phillipsi, Hyolithus primævus,* and a new species of *Obolella.*

The last rock, though now separated by faults from the older Malvern Series, contains angular fragments both of Uriconian and Malvernian type. It is correlated with the Wrekin Quartzite and with the lower divisions of the Hartshill Quartzite. The Flaggy and Shaly Beds appear to correspond with the *Olenellus*-beds and the zone of *Paradoxides Groomi* in Shropshire. The bulk of the Hollybush Sandstone probably represents the greater part of the Paradoxidian of other localities, and may in part correspond with the Purley Beds of Nuneaton.

[1] [This was originally termed by the author 'Hollybush Quartzite.']

The lower division of the White-leaved Oak Shales may represent the Swedish zone with *Beyrichia Angelini*, and perhaps the Festiniog Beds of North Wales. It is, however, more probable that it represents the uppermost portion of the Paradoxidian. The greater part of these shales, however, belongs to the zone of *Sphærophthalmus alatus*; but it is possible that other zones, both immediately above and immediately below, may be represented in the district. The middle part of the Bronsil Shales has yielded Asaphids and Olenids in association with *Dictyonema*, and may be correlated with the Tremadoc beds which yield the *Euloma-Niobe* fauna. The author prefers to endorse the Continental view of these rocks, and to group the Tremadoc Series with the Ordovician, with the reservation that the *Dictyonema*-shales of Europe should be regarded as belonging to the Tremadoc, the base-line of the Ordovician being drawn immediately below these shales.

The paper contains an account of the Hyolithidæ and trilobites of these rocks. Three new species of *Hyolithus* are named and described in full, and four in outline, while a revision of Holl's species *H. fistula* is given. Notes are also given, by Mr. Philip Lake and the author, on *Agnostus trisectus*, *Cheirurus Frederici*, and other trilobites, and a name is given to certain cylindrical bodies which appear to be the eggs or excreta of some animal.

In the Appendix on the Cambrian Brachiopoda of the Malvern Hills, after making a few brief remarks as to our present knowledge of these fossils, Mr. C. A. Matley proceeds to describe a new species of *Obolella* and a new variety of *Acrotreta Sabrinæ*. Species of *Lingulella*, *Lingula*, and *Acrotreta* are described, and a revision is given of *Obolella* (?) *Salteri*, *Lingulella Nicholsoni*, *Acrotreta Sabrinæ*, *Linnarssonia Belti*, and *Kutorgina cingulata* vars. *Phillipsi* and *pusilla*.

CORRESPONDENCE.

ADDITIONAL NOTE ON *AMMONITES CALCAR*, ZIETEN.

Sir,—Since writing the note on *Ammonites calcar*, Zieten, that appeared in the Geological Magazine for December, 1899 (pp. 554–558), there has been found belonging to the specimen there described another original label, which it seems desirable to record. This was fastened in the Museum register; not on the page where the specimen was entered, but some two leaves from the place, so that it was discovered quite by accident. Fortunately, when the specimen was registered the register number was written on the label, so that there can be no doubt whatever about the label belonging to this actual specimen. The label bears the following inscription in the handwriting of Dr. Bruckmann, from whom the fossil was obtained: "*Ammonites calcar* Benz; Zieten. Brown Jura ζ; Ornatenthon. Unic [*sic*] of Zieten's collection; *extremely rare!* Gamelshausen in Württemberg. Professor Dr. Kurr told me that he was about to buy the whole of Zieten's collection, only in order to get into possession of this specimen. Worth about £5. Quenstedt considers it to be a sick *Am. bipartitus.* Dr. Br." Although this label is in part merely a translation of the label already mentioned as accompanying the specimen, we think it confirms the opinion expressed in the former paper that this example is really Zieten's type-specimen. G. C. Crick.

British Museum (Natural History), S.W.
December 7, 1901.

SUB-FOSSIL YEW-WOOD.

Sir,—Dr. Conwentz, who has published papers on the spontaneous growth of the yew-tree in Germany, read a paper at the meeting (1901) of the British Association on the past history of this interesting tree in Great Britain and Ireland. By microscopical examination he has proved the occurrence of much sub-fossil yew-wood, particularly from buried peat-beds and submerged forests in this country; but he is anxious for more material from localities in England and Ireland, and he asks all who have an opportunity of collecting examples of reddish woods, looking like yew, to post to him small pieces for examination. His address is: "Prof. Dr. Conwentz, Director of the Museum, Danzig, Germany," and parcels should be labelled outside "Of no value." E. T. Newton.

OBITUARY.

SAMUEL ROWLES PATTISON.

Born 1809. Died November 27, 1901.

The death has been announced, on November 27, at Kensington, of Mr. S. R. Pattison, at the advanced age of 92. Mr. Pattison was elected a Fellow of the Geological Society in 1839. At this period he resided at Launceston, and there he gathered together a fine collection of fossils from the Upper Devonian Limestone of South Petherwin. These specimens and his local information were placed at the disposal of De la Beche and John Phillips when they were engaged on the geological survey in that part of Cornwall, and on the description of the organic remains. Pattison contributed a number of papers to the Royal Institution of Cornwall and the Royal Geological Society of Cornwall, on the geology of Launceston, Tintagel, and other places. In 1854 he drew attention to an auriferous quartz-rock in North Cornwall (Quart. Journ. Geol. Soc., vol. x, p. 247). In 1871, after a visit to the Franco-Belgian Devonian regions, he brought before the Geologists' Association a paper on the Upper Limits of the Devonian System. In 1849 he published a little work entitled "Chapters on Fossil Botany," and in 1858 "The Earth and the Word; or, Geology for Bible Students." Mr. Pattison was a member of a firm of solicitors, and his legal knowledge was for many years placed at the service of the Geological Society, on whose Council he served. A few years ago he resigned his fellowship of the Society.

THE

GEOLOGICAL MAGAZINE.

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No. II.—FEBRUARY, 1902.

ORIGINAL ARTICLES.

I.—Fossils from the Hindu Khoosh.

By Lieut.-Gen. C. A. McMahon, F.R.S., F.G.S., and W. H. Hudleston, M.A., F.R.S., F.L.S., F.G.S.

Part II.—Palæontology. By Mr. Hudleston.

(PLATES II and III.)

THE Himalayas, with the help of that singular replica of the more mountainous region known as the Salt Range, have afforded to the palæontologist, in one place or another, a fairly good series of the several Palæozoic horizons.

1. *The First Palæozoic Horizon.*—The lowest Cambrian, or *Neobolus*-fauna, perhaps the lowest recognized fauna in the world, is to be found in the Salt Range in immediate succession to the Salt series. This fauna was discovered by Warth, and has been elucidated in the *Palæontologia Indica* at considerable length. In the volume for 1899 there is a plate of these fossils, which are described as consisting of simple forms like *Neobolus*, or rather complicated ones like *Pseudotheca*.

The Carboniferous overlap in the Salt Range, noticed by Waagen and confirmed by subsequent observers, has had the effect of shutting out the rest of the infra-Carboniferous horizons from that range, so that we there obtain nothing between the lowest Cambrian and the Carboniferous beds. On the other hand, I cannot find that the *Neobolus*-fauna has been recognized in the Himalayas proper.

2. *The Second Palæozoic Horizon.*—This must be sought in the Himalayas alone without the valuable confirmatory evidence supplied by the Salt Range in the case of the Carboniferous fauna.

A very valuable find of fossils belonging to this horizon, which in the main may be regarded as of Lower Silurian (Ordovician) age, was made by General Strachey some forty years ago in Niti. These were described and figured by Salter in a memoir printed for private circulation, to which H. F. Blanford contributed. To give an idea of the importance of this find, Salter enumerated some sixty species, as follows:—Crustacea 8 species, Annelida 2, Cephalopoda 8, Gasteropoda 11, Lamellibranchiata 3, Brachiopoda 21, Bryozoa 3, Amorphozoa 2, Zoophyta 2. Referring to the Brachiopoda only, *Leptæna*, *Strophomena*, and *Orthis* are perhaps the best represented genera, and the fauna was regarded as most resembling Caradoc. Many of these fossils are in a fairly good state of preservation. The types are to be seen at the British (Natural History) Museum.

Shortly afterwards Stoliczka wrote a memoir on the Palæozoic formations in Spiti.[1] Here he came across a fossiliferous horizon which he called the *Bhabeh-series*, but the fossils were badly preserved. In his recapitulation Stoliczka described his Bhabeh-series as probably of Lower Silurian age, consisting of sandstones, slates, and quartzites, containing *Orthis* and other genera not specifically determinable.

Subsequently it is believed that important additions have been made to the collections from this horizon in the Himalayas, but at present these matters are in reserve. The following extract from Mr. R. D. Oldham's Manual,[2] published in 1893, bears upon this point. It occurs as a footnote. "A large number of fossils from General Strachey's collections were described by Messrs. Salter and Blanford in 1865, and the collections which were made by Griesbach, which are still in the course of description, will doubtless add to their number. Until this fauna has been worked out and its relations fully determined, there does not appear to be any benefit in printing a nominal list of the species that have been described."

3. *The Third Palæozoic Horizon.*—Like the second horizon, this has no replica in the Salt Range. So far as anything is known about it, we are still indebted to Stoliczka. Referring to his experiences in Spiti, he thus speaks of the *Muth-series* :—"Above the true Silurian rocks there will be found a thickness of beds, of about 1,000 feet, distinguished by a different shade of a bluish colour; their age is left undecided. The fossils of this series occur in an arenaceous limestone, some of the beds being of a purer limestone of a dark colour. Specific determination is not easy owing to the bad state of preservation."

Two species of *Cyathophyllum* were recognized, whilst the Brachiopoda were represented by *Strophomena* and two species of *Orthis*. In his summary Stoliczka regarded the Muth-series as of Upper Silurian age, and he correlated, as already stated by General McMahon, the middle or fossiliferous division of that series with the Blaini-limestone.

4. *The Fourth Palæozoic Horizon.*—This may be focussed under the general term of the *Kuling-series*. The fine collection of Carboniferous fossils sent by Colonel Godwin-Austen from Kashmir engaged the attention of Davidson many years ago.[3] A considerable number of these specimens may yet be seen in the Museum of the Geological Society. This very abundant and characteristic fauna is receiving ample attention from the writers in the *Palæontologia Indica*, supplemented as it is by the highly fossiliferous *Productus*-limestones of the Salt Range.

[1] Mem. Geol. Surv. India, vol. v, pt. 1.
[2] p. 115.
[3] Quart. Journ. Geol. Soc., vol. xx, p. 383, and vol. xxi, p. 492.

The preceding notice of the principal Palæozoic horizons in the north-west corner of India may, it is hoped, be useful before attempting to study General McMahon's collection in detail.

When these fossils were first placed in my hands I had no knowledge of any of the four Palæozoic horizons of India, with the exception of the last, and that only to a very slight extent. Naturally, therefore, I first of all tried the Carboniferous, though I was surprised at finding no species of *Productus* in the collection. After working on this tack for some time I found that there was nothing in Indian Carboniferous palæontology to encourage me to proceed. Accordingly I fell back on the Niti fauna of Lower Silurian age described by Salter. This seemed to be somewhat more hopeful, but at last I was driven to the conclusion that I could find nothing published on Indian palæontology which would throw any light on the Chitral fossils.

Trying nearer home, it soon became evident that there existed a certain relationship between these fossils and the recognized faunas of the Upper Silurian and Devonian as developed in our own country. The few Corals remind me of Wenlock species, whilst the Brachiopoda wear a Devonian aspect. This determination would bring the assemblage nearest to the Muth-series, though perhaps not actually identical with that scanty and ill-preserved fauna. As confirmatory evidence the fossils of the Muth-series are said to occur in an arenaceous limestone, some of the beds being of a purer limestone of dark colour.[1] The dark limestone corresponds very well with the matrix of the Chitral fossils. Moreover, it is interesting to remember that two species of *Cyathophyllum* are recorded from the Muth-series.

In the case of General McMahon's collection it cannot be said that the fossils are badly preserved; they are less drawn out and disfigured by pressure than many Devonian specimens from Devonshire or Cornwall. Some of the specimens remind one of Dudley fossils, except that the limestone is darker and probably more earthy. The specimens also in most cases are fairly free from matrix, and the numerous individuals of *Atrypa* are detached and clean. The shells are in the condition of calcite with a dark exterior. Unfortunately there are no good casts of interiors. The conclusions both in the case of Corals and Brachiopoda are largely based on external characters.

Enumeration and Description of the Fossils.

CORALS.

1. Favosites cf. cristata, Blumenbach. (Pl. II, Fig. 1.)

Favosites cristata: Brit. Foss. Cor. (Silurian), p. 260, pl. lxi, figs. 3, 4.

This identification rests mainly on comparison with specimens from the Wenlock Limestone of Dudley in my own collection. The external resemblance is very striking. There is less resemblance to the figures in the "British Fossil Corals." The following is the

[1] Vide supra, p. 50.

diagnosis of Edwards & Haime:—"Corallum dendroidal . . . . Calices somewhat unequal in size, often almost circular and with rather a thick margin." "This coral bears great resemblance to *Favosites* [*Pachypora*] *cervicornis* of the Devonian, and we were even doubtful as to its being specifically distinct from it; its calices are, however, less unequal in size and almost circular." *F. cristata* is said by these authors to occur likewise in the Devonian of the Ural Mountains.

In the specimen from Chitral a variation in the size of the calices in the left-hand branch of the corallum is observed, and this divergence of form may be held to favour the view as to its affinity with *Pachypora cervicornis*, so common in the Devonian of Torquay.

There is another specimen of *Favosites* (? *Pachypora*) in the collection, which is less markedly dendroid, and in which the calices are rather smaller; but this, I think, may be referred to the same species.

2. Cyathophyllum cf. truncatum, Linnæus. (Pl. II, Figs. 2, 3.)

Cyathophyllum truncatum: Brit. Foss. Cor. (Silurian), p. 284, pl. lxvi, figs. 5*a–c*.

Edwards & Haime's diagnosis is true of specimens from Chitral in the following particulars:—"Corallites regularly turbinate, not very tall, and narrow at their basis; walls covered with a thin epitheca, and presenting strongly marked accretion ridges . . . . central fossula large and rather deep . . . . septa (50 to 60) very closely set, and thick towards the circumference, rather thin towards the centre, rather unequal in length alternately; the largest reaching to the centre." On the other hand, there are minor points where Edwards & Haime's diagnosis can scarcely be said to apply, more especially as regards the flattening of the outer part of the calice.

The Chitral fossils greatly resemble specimens of *C. truncatum* from the Wenlock Limestone of May Hill, more than they do any Devonian species such as *Hallia Pengellyi* or *C. helianthoides*. *Cyathophyllum densum*, Lindström (Richthofen, China, Bd. iv, p. 65), may approximate.

There are five specimens in the collection which may be classed under this head, besides fragments of what may be other species of *Cyathophyllum*.

3. Cyathophyllum cf. articulatum, Wahlenberg. (Pl. II, Figs. 4, 5.)

Cyathophyllum articulatum: Brit. Foss. Cor. (Silurian), p. 282, pl. lxvii, figs. 1, 1*a*.

The corallites in the Chitral specimens are all detached, and hence taken singly do not compare well with the fine composite figures of Edwards & Haime. In other respects their diagnosis is fairly applicable. "Corallites sub-cylindrical, tall, presenting numerous prominent accretion ridges, and covered with a thin epitheca, through which the costæ are apparent. Calices circular, shallow." The state of preservation does not admit of further comparison. There is a specimen in my own (British) collection from Dudley or

May Hill, which is so like the Chitral specimens, even to the matrix, that only close examination would enable one to separate them.

Two or three specimens in General McMahon's collection may be thus referred.

BRACHIOPODA.

4. Orthis striatula, Schlotheim. (Pl. II, Figs. 6*a*, *b*, 7*a–c*.)

Orthis striatula, Schlotheim: British Devonian Brachiopoda, p. 87, pl. xvii, figs. 4–7.

Specimens of *Orthis* are rare in this collection, and owing to the slipping of the valves very much thrown out of shape. Hence the character of the ornamentation becomes the principal factor for specific determination. The smaller of the two figured specimens shows the *Orthis* hinge very distinctly, whilst the larger one fails in this respect. Davidson's diagnosis is sufficiently comprehensive—"Shell variable, usually transversely oval or elliptical, but at times the length is equal to or slightly exceeds the width." But for this I might have had some hesitation in thus classifying Fig. 6, which has a strong resemblance to *Orthis æquivalvis*, Dav. (Brit. Silur. Brach., p. 263, pl. xxx, figs. 9, 10). As regards the ornamentation, the following fairly well applies both to the larger and the smaller specimen: "Exteriorly, both valves are closely covered with numerous, fine, thread-like, rounded, radiating striæ, etc."

Genus SPIRIFER.

There are a great many specimens of *Spirifer* in General McMahon's collection, most of which can be focussed under some of the varieties of *Spirifer disjunctus*, Sowerby, as grouped by Davidson. In this respect it seems to me that Davidson has made his net a little too comprehensive.

5. Spirifer extensus, Sowerby. (Pl. II, Figs. 8*a–d*.)

Spirifera extensa, Sowerby: Trans. Geol. Soc., ser. ii, vol. v, pl. liv, fig. 11.
Spirifer disjunctus, Sow., var. *extensa*, Sow.: Brit. Dev. Brach., p. 23, pl. v, fig. 11.

Width of figured specimen 40 mm., length 18 mm. This gives a ratio of width to length of rather more than 2 : 1. Shell alate; valves moderately convex with a deep sulcus in the ventral valve, whilst the dorsal valve has the mesial fold very prominent; hinge area narrow and nearly straight. The beak of the ventral valve is only slightly incurved, and but slightly projecting. There are about 45 radiating costæ of moderate salience on each valve, and this style of ornamentation is shared by the sulcus and mesial fold.

The Chitral fossil differs from the type-form of *S. extensus* chiefly in being somewhat less alate, and in having a more pronounced mesial fold and sulcus. In this respect it more resembles *S. calcaratus*, Sow., which Davidson likewise regards as a variety of the *disjunctus*-group. It must be noted that besides the alate character of this fossil (Fig. 8) the narrow hinge area and want of salience of the beak of the ventral valve serve to separate it from *Spirifer disjunctus* (Fig. 9).

There are two specimens in the collection.

6. Spirifer disjunctus, Sowerby. (Pl. II: Rhomboidal variety, Figs. 9*a–c*, 10.)

Spirifera disjuncta, Sow.: Trans. Geol. Soc., ser. ii, vol. v, pl. liv, figs. 12, 13, and explanation of plate.
Spirifer disjunctus, Sow.: Davidson, Q.J.G.S., vol. ix (1853), p. 354, pl. xv, figs. 1, 2, 4; ibid., Brit. Dev. Brach., p. 23, pl. v, especially figs. 1, 4, and 5.
Spirifer Verneuili, Murchison: Kayser in Richthofen's China, Bd. iv, p. 88, pl. x, fig. 3.

Width of the larger figured specimen (Figs. 9*a–c*) 34 mm.; length 26 mm. This gives the width to length as 3 : 2 approximately. Shell rhomboidal, narrowing towards the anterior margin so as to produce a curved outline; valves moderately convex. The sulcus and mesial fold are moderately developed, and carry nearly the same ornaments as the rest of the shell (faintly seen in the specimen owing to attrition). These ornaments consist of from 50 to 55 regular and equidistant costæ. Hinge area wide and triangular, the ventral valve greatly overlapping.

(Quadrate variety, Figs. 11, 12*a–c*.)

This variety is shown on Davidson's plate in the Q.J.G.S. by the figs. 3 and 5, and in the Brit. Dev. Brach. on pl. v, fig. 6.

Ratio of width to length very nearly as 1 : 1. Shell quadrate, valves usually somewhat tumid. Sulcus in ventral valve wide and not very deep; fold on the opposite valve correspondingly wide; ornaments the same throughout. Area moderately wide and trigonal in shape; beak of ventral valve considerably produced and incurved.

There are about half a dozen specimens of the rhomboidal form in the collection from Chitral, and rather more of the quadrate form, together with some which may be deemed intermediate.

The geographical distribution of this species is interesting. Davidson's specimens were described from Kwang-si, a province in the south of China. Herr Kayser's illustrations of this species occupy more than half of a quarto plate from collections made by Richthofen in south-west China.

7. Spirifer, species. (Pl. III, Figs. 1*a–c*.)

Shell ovate; width to length rather less than 3 : 2. Ventral valve very tumid, and with umbo considerably incurved; area small and closed. Sulcus and mesial fold not very conspicuous. The ornaments consist of numerous fine radial striæ.

The restricted area and fine radial striæ, together with its ovate form, seem to separate this from the *disjunctus*-group. There is only one specimen, somewhat indifferently preserved. The internal mould, which is partly exposed, consists of a very black and probably impure limestone, the shell itself being constituted of a brownish calcite.

8. Athyris concentrica, Von Buch. (Pl. III, Figs. 2*a–c*.)

Terebratula concentrica, Von Buch: Ueber Terebrateln, p. 103, Berlin (1834).
Athyris concentrica, Von Buch: Brit. Dev. Brach., p. 14, pl. iii, figs. 11–15, 24.

The figured specimen conforms pretty well to the diagnosis given by Davidson, which at least should confirm the view that this shell is a species of *Athyris.* The following especially applies to our specimen:—"Beak tumid, moderately produced, incurved and truncated by a small circular aperture close to the umbone of the opposite valve; surface more or less deeply marked by numerous close, concentric, regular, imbricating laminæ of growth." In our shell there is just enough left of these imbricating laminæ in the sulcus of the ventral valve to show what the ornaments of the shell originally were.

There are three specimens in the collection, but this is the only one showing the concentric ornamentation.

9. Athyris, species or variety. (Pl. III, Figs. 3*a–c.*)

This is a very strongly marked form, and might in some sense be described as an exaggerated variety of *A. concentrica.* The features of that species, such as the sinus on the ventral valve and the mesial fold on the dorsal valve, as likewise the imbricating concentric ornamentation, are intensified. The principal difference consists in the great predominance of the ventral valve in the region of the beak, almost recalling the outline of *Pentamerus.*

There is one specimen, in by no means a bad state of preservation.

Genus ATRYPA.

Nearly half the Brachiopoda in General McMahon's collection belong to this genus, and the specimens are for the most part free from matrix, whilst some are fairly well preserved. There is considerable uniformity as to size and shape, and the ornaments, as a rule, are strongly imbricated. Hardly any of the specimens present the fine lines of *Atrypa reticularis,* and moreover the prevailing shape is too circular for that species. The Chitral fossils more nearly approach *Atrypa aspera* and its numerous varieties, and under this species it will be convenient to focus the whole group.

10. Atrypa aspera, Schlotheim. (Pl. III, Figs. 4, 5*a, b,* 6*a, b,* 7*a, b.*)

Atrypa aspera, Schlotheim: Brit. Dev. Brach., p. 57, pl. x, figs. 5, 6.
Ibid., var. *squamosa,* Sow.: Brit. Dev. Brach., p. 57, pl. x, figs. 7, 8.
Ibid., var. *Sinensis,* Kayser: Richthofen's China, Bd. iv, p. 83, pl. ix, fig. 3.

Davidson classified *Atrypa aspera* simply as a variety of *A. reticularis,* and he further remarks that it is always found in the same beds and localities where the latter occurs and abounds. The important point for us to consider is the fact that, whereas *A. reticularis* is equally abundant in the Upper Silurian and Devonian, *A. aspera,* be it species or variety, occurs mainly in the Devonian, its place in the Upper Silurian being occupied by *A. imbricata,* Sow. As to the existence of intermediate forms, no doubt the affinity of every variety of *Atrypa* may be traced to the prevailing form, viz. *reticularis,* if one is so inclined.

In dealing with the Chitral fossils, Fig. 5*a* may be accepted as an average specimen, very well preserved as regards ornaments, but rendered somewhat quadrate in appearance by a slight slipping of the valves. The dorsal valve is shown with the very small beak of the ventral valve just projecting beyond the hinge-line. The radial costæ are salient, rounded, and highly imbricated, especially anteriorly (Fig. 5*b*).

In Fig. 6 we have a larger but less well-preserved fossil, and the original outline was probably less circular. This may be regarded as more nearly approaching *A. reticularis*; an enlargement, however, would show the costæ to be strongly imbricated and almost squamose. The valves as a rule are moderately tumid, the dorsal valve usually the most so.

Fig. 4 is a good example of the var. *squamosa*, Sowerby. In this case the circular outline is well shown, whilst the highly squamose character of the anterior portion of the shell is obvious.

Figs. 7*a*, *b* represent a perfectly circular and slightly globose form of medium size with very large imbricated costæ. This may be compared with the var. *Sinensis* of Kayser, though specimens from China would seem to have the dorsal valve less tumid.

11. Atrypa, species or variety. (Pl. III, Figs. 8*a*–*c*.)

This form is an exaggeration of the small circular variety of *Atrypa* last described. Both valves are extremely tumid, so that the shell is almost as globose as a ball. The only available specimen is much abraded, but it is possible to perceive that the costæ were highly imbricate, and that there are indications of a shallow sinus and slight mesial fold.

12. Cf. Rensslæria stringiceps, F. Römer. (Pl. III, Figs. 9*a*–*c*.)

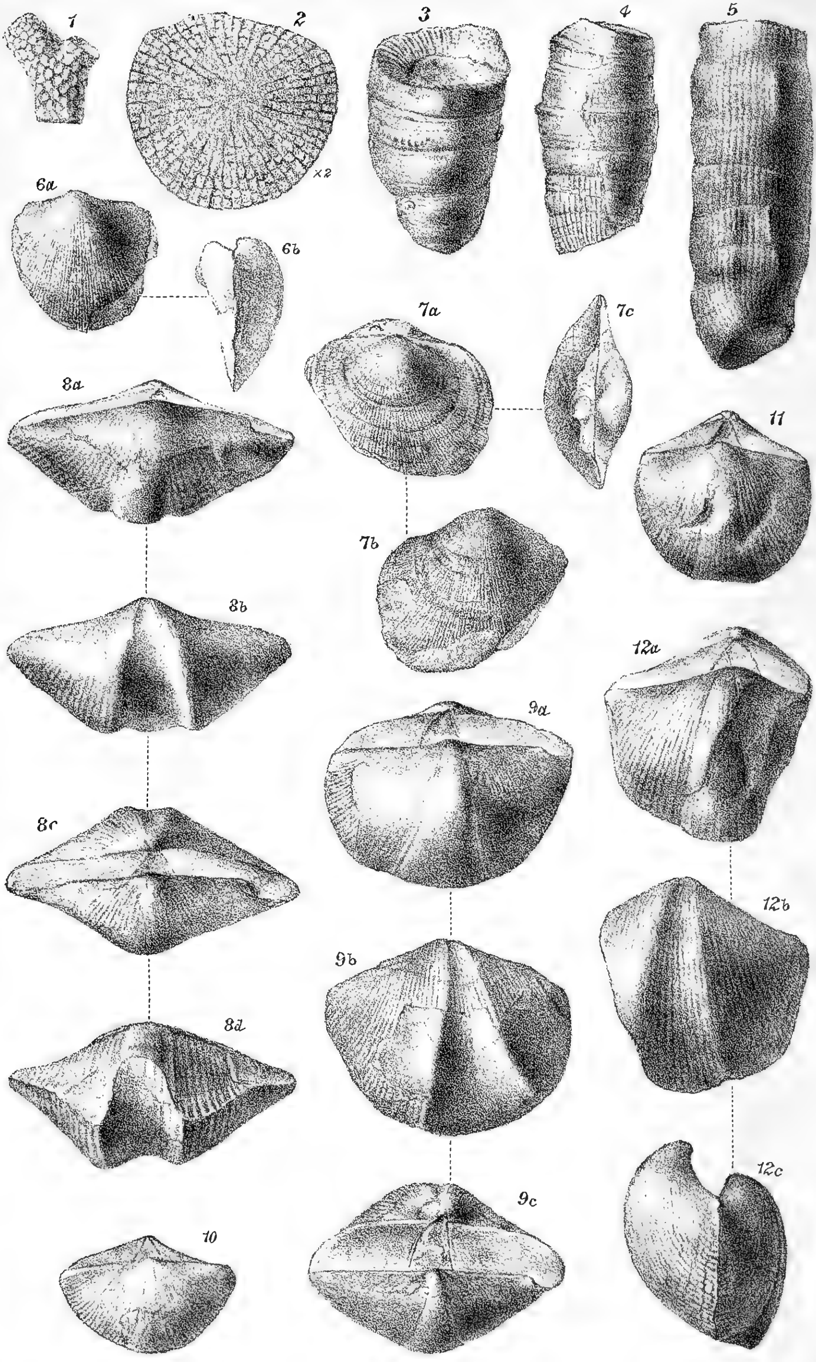
Rensslæria stringiceps ?, F. Römer: Brit. Dev. Brach., p. 10, pl. iv, figs. 5–7.

A single specimen, somewhat indifferently preserved in very black limestone, bears great resemblance to the fossil figured by Davidson under the above appellation. It is a terebratuloid shell, with a beak apparently possessed of a circular foramen: shape oblong, valves tumid, especially the dorsal valve. The dorsal valve swells out rapidly from the hinge area; the ventral valve has a slight median ridge, increasing in sharpness towards the beak. The valves are ornamented with strong radiating nodular costæ, about 20 in each valve.

13. Rhynchonella, species. (Pl. III, Figs. 10*a*–*c*.)

Shell transversely oblong; length 18 mm., estimated width 28 mm. Dorsal valve ventricose; ventral valve inclined to be flat, and provided with a wide, shallow sinus towards the anterior margin, which is only slightly sinuous. From 30 to 35 medium-sized costæ increase regularly towards the anterior margin without interpolation.

This is the only specimen in the collection which can be confidently referred to *Rhynchonella*. It is an average sort of form, which may possibly have some relationship to *R. parallelopipeda*, Bronn (vide Richthofen's China, Bd. iv, p. 77, pl. viii, fig. 1).



Geo. West lith.

FOSSILS FROM THE HINDU KHOOSH.

Other Fossils.

In addition to the species already enumerated we perceive indications of other organized forms.

1. There are, for instance, other species of Brachiopoda, too obscure for identification.

2. Impressions of what seem to be crinoidal joints.

3. The frequent occurrence of *Spirorbis* as an adherent body. This is similar to those occurring on fossils from the Upper Silurian of Dudley, and also on Devonian fossils. Cf. Kayser in Richthofen's China, Bd. iv, p. 95, pl. xi, fig. 2, under the heading *Spirorbis omphalodes*, Goldf.?

4. The most interesting and abundant micro-organism is an incrusting Coral or Monticuliporoid, often well developed on the stem of *Cyathophyllum*. The size and character of the mesh resemble *Monticulipora* or *Chætetes*, but as the substance is too thin to bear cutting one can only conjecture its generic affinities.

A growth apparently identical in form is quite common on Corals from Dudley, and notably on a specimen of *Thecia* in my collection. In the British (Natural History) Museum there is a specimen of this incrusting organism on *Spirifer plicatella*. This specimen is labelled *Heterotrypa*, sp. (Allport, coll. D, 1752). The incrusting body on the Chitral fossils appears to be the same.

Conclusion.

There can be no doubt that these fossils from Chitral indicate the existence of a Devonian horizon in that region. The Brachiopoda are unmistakably Devonian, whilst the Corals, if rightly identified, point rather to species of Wenlock age. This difference may arise from one of three causes—either (1) the identification of the Corals is not wholly satisfactory; or (2) the Corals may have been obtained from slightly lower beds; or (3) there is a mixture of Upper Silurian and Devonian forms.

It must be distinctly understood that no attempt has been made to found new species. Identification, if only approximate, has been my object throughout. In the case of the first Coral enumerated (Pl. II, Fig. 1), it belongs to a form-group which may be either Silurian or Devonian, since we have the evidence of Edwards & Haime that they were doubtful if a true distinction could be made between *Favosites cristata* and [*Pachypora*] *cervicornis*, the one an Upper Silurian, the other a Devonian species.

The existence of a Devonian horizon in Eastern and Central Asia must henceforth be regarded as established beyond any doubt. Probably the first notice of the occurrence of Devonian fossils in China was given by De Koninck, who described a *Spirifer* and a *Rhynchonella* from Yunnan.[1] I have already referred to Davidson's recognition of Devonian fossils from the Chinese province of Kwang-si (near Canton). From south-western China Richthofen

[1] Bull. de l'Acad. Royale de Belgique, 1846.

obtained a large series of fossils, which Kayser regarded as Devonian. In vol. iv of Richthofen's China, Herr Kayser recognizes 14 species as previously known and 14 as new—all of Devonian age.[1] So much, then, for Devonian beds in China.

Proceeding westwards, we next find traces of a Devonian fauna in the Shan states of Burmah. The following is from a report of the Geological Survey of India (March 31, 1901): "The occurrence of Devonian, which had been inferred by Mr. P. N. Datta, has been confirmed by Mr. La Touche, who found *Calceola sandalina.*"[2] It is a far cry from northern Burmah to Chitral; nevertheless, over a range of 2,000 miles from hard by the Pacific near Canton to the very centre of the Hindu Khoosh there are four or five points where a Devonian fauna has been proved to exist in regions not particularly accessible to the palæontologist. Our thanks are therefore due to General McMahon and his able coadjutors in Chitral for having brought this interesting series of fossils to light.

EXPLANATION OF PLATE II.

N.B.—All the figures are drawn from photographs; except Fig. 2 they are all of natural size.

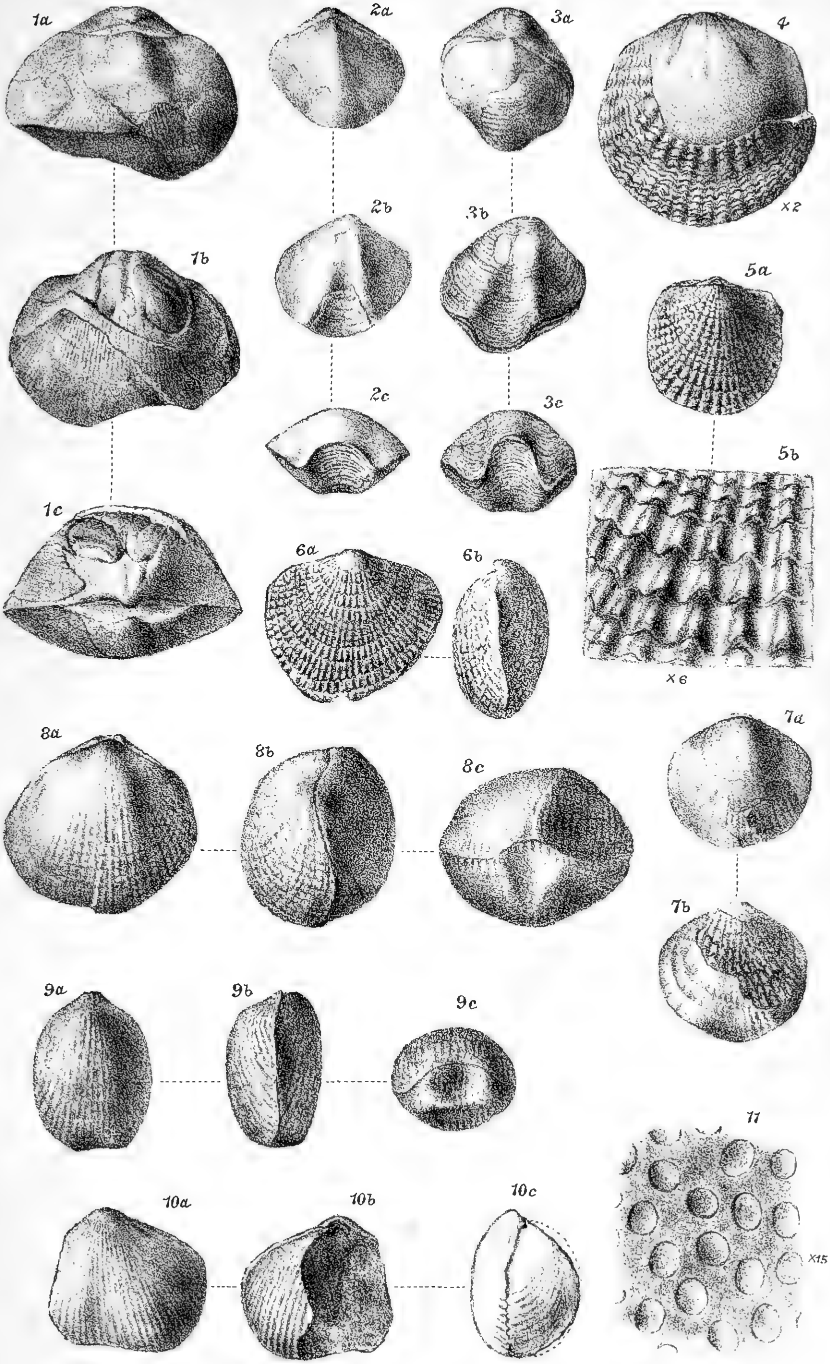
Fig. 1.—*Favosites* cf. *cristata*, Blumenbach. Portion of dendroid corallum.
Fig. 2.—*Cyathophyllum* cf. *truncatum*, Linnæus. Transverse section. × 2.
Fig. 3.—Ibid. Longitudinal view of another specimen, showing the calice.
Fig. 4.—*Cyathophyllum* cf. *articulatum*, Wahlenberg. Longitudinal view, showing accretion ridges.
Fig. 5.—Ibid. Another specimen with the ridges abraded.
Figs. 6*a*, *b*.—*Orthis*, species; ? small variety of *O. striatula*, Schlotheim.
Figs. 7*a–c*.—*Orthis striatula*, Schlotheim.
Figs. 8*a–d*.—*Spirifer extensus*, Sowerby.
Figs. 9*a–c*.—*Spirifer disjunctus*, Sowerby. Rhomboidal or type form.
Fig. 10.—Ibid. A smaller specimen, with fine striæ.
Fig. 11.—Ibid. Quadrate form.
Figs. 12*a–c*.—Ibid. A larger specimen of the quadrate form.

EXPLANATION OF PLATE III.

N.B.—All figures natural size, except Figs. 4, 5*b*, and 11, which last is cancelled.

Figs. 1*a–c*.—*Spirifer*, species.
Figs. 2*a–c*.—*Athyris concentrica*, Von Buch.
Figs. 3*a–c*.—*Athyris*, species or variety.
Fig. 4.—*Atrypa aspera*, Schlotheim, var. *squamosa*, Sowerby. × 2.
Fig. 5*a*.—*Atrypa aspera*, Schlotheim. 5*b*, portion of test; × 4.
Figs. 6*a*, *b*.—*Atrypa aspera*, Schlotheim, approaching *Atrypa reticularis*, Linnæus.
Figs. 7*a*, *b*.—*Atrypa aspera*, variety approaching var. *Sinensis*, Kayser.
Figs. 8*a–c*.—*Atrypa*, species or variety.
Figs. 9*a–c*.—Cf. *Rensslæria stringiceps*, F. Römer.
Figs. 10*a–c*.—*Rhynchonella*, species.
Fig. 11.—Cancelled.

[1] I am indebted to Mr. R. Bullen Newton for drawing my attention to Herr Kayser's important work.
[2] *Nature*, Aug. 8, 1901, p. 359.



FOSSILS FROM THE HINDU KHOOSH.

II.—The Relation of Changes of Level to Interglacial Periods.

By Professor A. P. Coleman, Toronto University, Canada.

THE interesting paper on "The Connection of the Glacial Period with Oscillation of the Land," by Dr. Holst,[1] while reinforcing the quite probable theory that areas loaded with glacial ice sink under the burden, and after the ice has been thawed rise again, goes out of its way to deny the existence of Interglacial periods, probably with the idea that there was only one important sinking and rising in the Pleistocene, and hence no opportunity for Interglacial times. However that may be in Sweden, the evidence in favour of at least one important Interglacial period in North America is too strong to be set aside for any mere theory.

At the Meeting of the British Association in Toronto in 1897, a number of British geologists had an opportunity of seeing sections of the drift in the Don valley and at Scarboro' Heights near Toronto, which show a very extensive series of sediments, rich in fossils, lying between two well-defined sheets of Boulder-clay.

A committee was appointed to work out in detail the relationships of these Interglacial beds, and the secretary of the committee, the present writer, aided by generous grants from the Association, carried on a series of explorations the results of which were reported at the three following meetings. A detailed summing up of the facts observed, giving sections and lists of about 180 species of plants and animals, chiefly forest trees, fresh-water shellfish, and beetles, but including elephants, bison, and caribou, was published last Summer in the Journal of Geology.[2]

In a few words the general character of the facts observed may be given here, so that the strength of the evidence may be appreciated; and lest there should be any doubt as to the reality of the Interglacial position of the beds in question, it may be stated that they have been visited by numbers of glacialists from the United States as well as the Old World, some of them strongly opposed to the idea of Interglacial periods; but all have admitted that they are really Interglacial, though there have been differences of opinion as to whether the ice-sheet completely vanished during the time of their deposition, or merely withdrew to a greater or less distance and then advanced again.

The Interglacial beds consist mainly of a series of lake deposits, sands and clays, probably formed as a delta at the mouth of a large river. They are more than 186 feet in thickness at some points, and at least 18½ miles wide along the shore of Lake Ontario; while they have been traced inland more than 6 miles, beyond which they are buried under glacial materials.

At the base of the series, resting on an eroded surface of Boulder-clay, are 41 feet of the Don beds, containing, according to Professor

[1] Translation by Dr. F. A. Bather: Geol. Mag., May, 1901, pp. 205–216.

[2] "Glacial and Interglacial Beds near Toronto": Journn. Geol., vol. ix, No. 4, pp. 285–310.

Penhallow, an assemblage of forest trees like that of Ohio or Pennsylvania, some of them reaching their northern limit to the south of Toronto, others still growing in southern Ontario. One of them, *Acer pleistocenicum*, is extinct. Tree trunks 18 inches across are found at various levels in the Don beds, generally too much flattened by the pressure of the later ice-sheet to permit of counting their annual rings, though one that was better preserved than usual was found to have 120 rings in a width of 4 inches, and must have been 7 inches in radius when complete, i.e. 200 years old. These trees occur at the very bottom of the beds as well as at several levels above, and must represent different generations of forest. The upper or Scarboro' beds contain trees and other plants as well as beetles, of a cool temperate climate, like that of the north shore of Lake Superior, according to Dr. Macoun and Dr. Scudder. There are no Arctic nor sub-Arctic forms among them, and no glaciated pebbles nor ice-transported boulders; and the stratified clay is more ferruginous and less calcareous than any of our stratified glacial clays, burning to red brick instead of grey brick like the latter. The large river which formed the delta must have drained the upper lakes by a direct channel from Georgian Bay on Lake Huron to Scarboro' on Lake Ontario, and could not have drawn its waters from glacial sources.

It may be noted that at the very beginning of these Interglacial beds trees, such as three species of oak, an elm, the red cedar, and the pawpaw, were growing in the Don valley, showing that the climate was already warm, the last tree indicating a dry and hot Summer like that of Ohio. The isotherms evidently ran 150 miles north of their present position in eastern America.

Let us now turn to another side of the evidence. At the beginning of the deposits the water in the Ontario basin stood no higher than at present, perhaps lower, for streams eroded their channels through the Boulder-clay, and even 16 feet into the solid rock beneath, as shown in one of the Don sections. Afterwards the water in the basin rose to 60 feet above Lake Ontario at the end of the Don beds, and to 152 feet or more above that level before the close of the Scarboro' beds. There is no doubt about this point, for the deposits may be followed for miles with fine and even stratification, and could not have been formed by glacial rivers on a sloping land surface, as suggested by Mr. Warren Upham.[1]

Afterwards there was a fall in the level of the water to a point much below that of Ontario, and rivers had time to cut valleys more than 150 feet deep and from a mile to five miles in width through the Interglacial clay and sand. We have, therefore, an interval of erosion with low water after the retreat of the earlier ice-sheet before the warm-climate beds were laid down; and a very long stage of erosion with still lower water after the cold-temperate-climate beds were deposited; while there was a stage of high water between. How shall we account for these changes in the Interglacial water-levels?

[1] Amer. Geol., vol. xxviii, No. 5, p. 315.

Only two explanations have been suggested, an ice dam at the outlet of Lake Ontario, or an epeirogenic uplift of the region to the north-east, like that proved by Dr. Gilbert to be now going on in the Great Lakes region, followed by a sinking of the land again.

It seems incredible that after centuries, if not thousands, of years of hot summers like those of Pennsylvania the ice-sheet should still be lingering at the Thousand Islands, and should even advance 50 miles to the south, forming a wall of ice 200 or more feet thick across the powerful Interglacial St. Lawrence river. If the ice could thus advance during the warm climate epoch, why did it withdraw again after the climate had become cooler?

The improbabilities of the ice-dam theory are too great, and we must turn to the other theory of an uplift to the north-east followed by a depression for a satisfactory solution of the problem. Here a point of interest in connection with Dr. Holst's thesis makes its appearance. If during the warm Interglacial period there was a great differential uplift toward the north-east, was it not due to the thawing of the Labradorean ice-sheet, supposed to have been a mile or even two miles thick, and the resulting relief from pressure?

The supposition seems probable; and, since the water was ponded back to a height more than 150 feet above the present level, may we not suppose that Labrador toward the end of the time of deposit stood hundreds and possibly thousands of feet higher than now? Such an elevation towards the north-east would have rendered the climate of Labrador much colder; and, perhaps aided by changes in the constitution of the atmosphere or other causes, may have started a fresh accumulation of ice, which as it thickened pressed down the region and thus drained off the Interglacial lake and allowed rivers to cut their valleys.

Finally, the last ice-sheet, after advancing over the whole region, thawed, and the slow elevation toward the north-east began again. The distortion of the old Iroquois beach, as shown by the work of Drs. Spencer and Gilbert, gives an idea of how much elevation has been regained, and Dr. Gilbert's work in connection with lake-levels proves that the process is still going on; though the last vestige of the Labradorean ice-sheet long ago disappeared.

Apparently these changes of level are very much in arrears of the changes of load, and it may take even thousands of years for the earth's crust to readjust itself after a burden has been removed. We must not think of the solid rock or lithosphere as a thin crust resting on a molten layer, but as merging downwards into a plastic layer—Dr. Murray's tectosphere—which can yield to long-applied pressure and flow sluggishly to each side. After the pressure is removed, it returns in an equally sluggish way. If this conception of earth-movements is correct, the idea of motions due to the elasticity of the crust, like a pendulum set free, as suggested by Dr. Holst, must be abandoned. The rocks forming the lithosphere are not appreciably elastic, nor is the tectosphere a fluid that responds quickly to changes by successive waves slowly dying out. The surface cannot rebound beyond the level appropriate to its specific gravity, but is likely through friction to halt somewhat below that point.

It is probable that the return of the plastic substratum after the load has been removed is not at a uniform rate, perhaps because of halts in the recession of the ice or even of temporary advances during the time of general retreat; and thus the successive marine terraces found, for instance, on the lower St. Lawrence would be accounted for.

One other point seems worthy of discussion, as to whether the pre-Glacial and Interglacial elevation of the north-east of America was sufficient to account for an Ice Age without other aid. The evidence of the submerged channels of the St. Lawrence and other rivers points to a former elevation of about 3,000 feet above the present level. It is doubtful if that would place Labrador above snow-line under existing climatic conditions, since the present level of the country is not more than one or two thousand feet. Snow-line in the Rocky Mountains and Selkirks at the same latitude ranges from 9,000 to 7,500 feet; and even with the difference due to cold oceanic currents, 4,000 or 5,000 feet seems too low an average level for perpetual snow in central Labrador.

The elevation of Scandinavia, where there are now mountains 8,000 feet high, with numerous snowfields 3,000 or 5,000 feet higher, would no doubt under present conditions produce a great extension of the ice, perhaps covering most of the land; but would it push ice-sheets across the Baltic and North Sea to Germany and England? This seems very improbable; and some supplemental cause should perhaps be sought for, but a discussion of such wide questions would lead us too far.

III.—On an *Alveolina*-Limestone and Nummulitic Limestones from Egypt.

By Frederick Chapman, A.L.S., F.R.M.S.

Part I.

The following description of Egyptian foraminiferal limestones is based on a series of specimens transmitted to me by Dr. H. Woodward, F.R.S., on behalf of Captain H. G. Lyons, F.G.S.

The series comprises specimens from the Eocene and Miocene of the eastern side of the Red Sea Hills, collected by Mr. Thomas Barron, F.G.S.; and specimens from the Eocene of the east side of the Nile, between Assiut and Qena, and from the Baharia and Farafra Oases, collected by Mr. H. J. L. Beadnell, F.G.S. A great amount of interest attaches to these rocks, both as regards their general character and preservation, and also with respect to their microzoic contents.

The present series of rock-specimens may be described as follows:—

No. 2,195, 1*h*. "*Heterostegina*-limestones, 2 kilometres north-west of Camp 49, Wadi Dara, east of Red Sea Hills. Outlier of Miocene on Eocene and Cretaceous" (T. Barron). (Pl. IV, Fig. 1.)

An ochreous limestone, partly dolomitic. The interstitial material originally calcitic, but now largely replaced by minute rhombohedral crystals of dolomite. A few subangular and rounded quartz-grains also occur in this rock, the larger ones exhibiting a coarse polysynthetic structure under polarized light, such as may be seen in fragments derived from secondary quartz-veins.

The *Heterosteginæ* have been subjected to some considerable amount of pressure and are more or less deformed; the thin discoidal tests are often bent, and occasionally fractured over and against the larger quartz-grains. The tests of *Heterostegina depressa* constitute a large proportion of the limestone, perhaps as much as 90 per cent. Associated with the *Heterosteginæ* we notice many specimens of *Amphistegina Lessonii*, and in one section of the rock a crushed specimen of *Alveolina* was noted, presumably derived. Besides the foraminifera, there are several sections of polyzoa and some traces of lamellibranch shells.

Miocene.

No. 1,622, 56*h*, and No. 1,622, 6*k*. "Limestone under Eocene nodular bed near Jebel Hamrawein" (T. Barron). (Pl. IV, Fig. 2.)

This limestone contains a large proportion of a small variety of *N. curvispira*. There are apparently no other organisms present in the rock. The groundmass of this limestone is well crystallized, and contains numerous brown, indefinite-shaped glauconite grains. The specimen 56*h* contains nodules of chert which show a gradual passage from the limestone into the chert, the latter being isomorphous with the former as regards the organic contents. In the passage zone between the limestone and the chert a great deal of dolomite is present in the form of small rhombohedral crystals. In connection with these facts it is worth noting similar occurrences in many of the Devonian and Carboniferous cherts of England, and it seems to point to a certain sequence of chemical changes which occur in the silicification of limestones.

Middle Eocene: Mokattam Series.

No. 3,535, 52*l*. "Nummulitic limestones with bryozoa. Corner of cliff north of Salamuni, between Assiut and Qena, east side of Nile" (H. J. L. Beadnell). (Pl. IV, Fig. 3.)

A pure white chalky or earthy limestone with many nummulites, both large and small, and some *Operculinæ*. The groundmass of this rock is very finely crystalline, and was most probably a chalky mud in its original condition. It contains *Operculina complanata* var. *pyramidum*, *Nummulites Beaumonti*, and *N. sub-Beaumonti*.

Eocene: Upper Libyan or Lower Mokattam Series.[1]

[1] The fauna of this and the following specimens appears to be homotaxial in part with the Lower Mokattam beds found farther to the north, and this view is shared by Mr. Beadnell, who has written to me on the subject in a letter dated 6th April, 1901.

Box G, No. 1,467*d*. "Nummulites from a locality 39 kilometres west of Bawitti, on plateau west of Baharia Oasis" (H. J. L. Beadnell).[1]

A collection of nummulites of one kind, namely, *N. Gizehensis* var. *Pachoi*; these specimens are greatly worn and sand-polished. Also a small fragment of limestone crowded with specimens of *N. curvispira*.

Eocene: Upper Libyan or Lower Mokattam Series.

Box M, No. 1,480*e*. "*Operculinæ* and nummulites, 39 kilometres west of Bawitti, on plateau west of Baharia Oasis" (H. J. L. Beadnell). (Pl. IV, Fig. 4.)

The micro-structural features of this limestone are rather peculiar. Apparently the interstitial mud has crystallized round the nummulites, and during this process the cement has contracted so as to leave interspaces in the rock. The resultant cavities have subsequently been partially or entirely filled with little geodes of secondary quartz, showing a polysynthetic type of structure under polarized light with the microscope. This condition of the limestone seems to render it almost proof against weathering action. The rock is rather variable in its colour and appearance, and presents a pale cream to a dark reddish tint, due to the varying amounts of iron-staining. The surfaces of some of the rock-specimens are wind-polished. In mineralogical structure some of the samples have almost passed into the condition of Beekite.

The following foraminifera occur in this rock: *Textularia* ? *gramen*, *Globigerina bulloides*, *Operculina complanata* var. *discoidea*, *Nummulites Gizehensis* var. *Pachoi*, *N. curvispira*, *N. discorbina*, *N. subdiscorbina*, and *Orbitoides* (*Discocyclina*) *dispansa* (= *O. dilabida*, Schwager).

Eocene: Upper Libyan or Lower Mokattam Series.

Box M, Nos. 3,335*b* and *c*. "*Alveolina*-limestone, western wall of depression of Farafra Oasis (El-Guss-Abu-Said)" (H. J. L. Beadnell). (Pl. IV, Fig. 5.)

A white or pale cream-coloured limestone, having a soft crumbling texture, and crowded with *Alveolinæ*. The fractured surface of the rock is seen to be thickly studded with these foraminifera, or shows numerous cavities where they have dropped out. A rudely stratified structure is seen in weathered surfaces of this limestone, or where it has been subjected to wind-wearing action.

The groundmass of this rock seen under the microscope is finely granular, but crystalline; and the interior of the organisms are usually filled with calcite crystals, larger than those of the cement, a result of slower growth.

Four species of Ostracoda were found in the disintegrated rock, viz., *Bairdia subdeltoidea*, *B. Beadnelli* sp. nov., *B. minuta* sp. nov., and *Cythere farafrensis* sp. nov.

[1] In his paper on "Recent Geological Discoveries in the Nile Valley and Libyan Desert" (London, 1901), Mr. Beadnell refers in detail to the relations of the Cretaceous and Eocene at the above-named locality, and regards the nummulitic and *Operculina* limestones as Upper Libyan (p. 12 op. cit.).

As remarked above, the larger proportion of the rock is composed of foraminifera belonging to the genus *Alveolina*; but there are several other genera present, considerably smaller in size and much rarer. The list is as follows: *Miliolina inflata, Alveolina ellipsoidalis, A. decipiens, A. decipiens* var. *dolioliformis, A. pasticillata, Placopsilina cenomana, Valvulina Schwageri* sp. nov., *Bulimina elegantissima* var. *seminuda, Discorbina parisiensis, Truncatulina candidula, T. Ungeriana, Heterostegina depressa, Nummulites Biarritzensis* var. *præcursor.*

Eocene: Upper Libyan or Lower Mokattam Series.

Box M, No. 1,531*f.* "Nummulitic and *Operculina* limestone, 8 kilometres north of Mandisha, Baharia Oasis" (H. J. L. Beadnell).

A shaly, ochreous-stained limestone. Nummulites and *Operculinæ* largely make up the mass of the rock. A few fragments of a vesicular lamellibranch shell-structure (*Ostrea*?) occur in thin sections of this limestone.

The foraminifera yielded by this rock are: *Globigerina cretacea* (? derived), *Operculina complanata* var. *canalifera* (=*O. libyca*, Schwager), *Nummulites Ramondi*, and *N. variolaria.*

Eocene: Upper Libyan or Lower Mokattam Series.

Box M, No. 3,348*g.* "Nummulites and *Operculinæ.* Cliff 8 kilometres N.N.W. of Bawitti, Baharia Oasis" (H. J. L. Beadnell). (Pl. IV, Fig. 6.)

A pale ochre-yellow limestone with numerous cavities once occupied by nummulites and *Operculinæ.* The entire substance of this rock has undergone chemical and molecular change. The cementing material, as seen under the microscope, is recrystallized and dolomitized, whilst the cavities representing the nummulites and shells are either filled with calcite, or, as in the case of the larger nummulites and *Operculinæ*, represented only by hollow casts, or skeleton whorls bordered by dolomite rhombs. The surfaces of the cavities of the foraminiferal casts sometimes show a distinct septation, so much so as to leave no doubt regarding the identity of at least two species of the foraminifera.

The foraminifera present in this rock appear to be *Operculina complanata* var. *canalifera, Nummulites* ? *Biarritzensis* var. *præcursor*, and *N. Guettardi* var. *antiqua.*

Eocene: Upper Libyan or Lower Mokattam Series.

Box M, No. 1516*h.* "Nummulites, 17 kilometres N.N.E. of Ain-el-Haiss, Baharia Oasis" (H. J. L. Beadnell).

A series of nummulites comprising two species in about equal proportion, namely, *N. Beaumonti* and *N. sub-Beaumonti.*

Eocene: Upper Libyan or Lower Mokattam Series.

OSTRACODA.

BAIRDIA, McCoy [1844].

Bairdia subdeltoidea (Münster).

Jones & Sherborn, 1889: Monogr. Tert. Entom., Pal. Soc., p. 16, pl. i, figs. 15*a*, *b*.
Chapman, 1900: Geol. Mag., Dec. IV, Vol. VII, p. 4.

A species nearly allied to the above, namely, *B. foveolata*, G. S. Brady, is found in recent deposits,[1] and our Egyptian specimens are not unlike it as regards the superficial markings on the carapace, but the lateral view of the recent species has an outline which is perhaps more nearly comparable with that of *B. subtrigona*, Bornemann.

Formerly recorded from Egypt from an *Alveolina* - limestone doubtfully referred to Lower Miocene, from a locality between Cairo and Suez.

Two specimens measuring in length 1·7 mm. and 1·2 mm. respectively.

Found in No. 3,335*b*, *Alveolina* - limestone. Farafra Oasis: Libyan Series.

Bairdia Beadnelli, sp. nov. (Pl. V, Figs. 1*a–c*.)

Carapace elongated, somewhat compressed; height equal to half the length, and situated in front of the middle. Laterally the shape is somewhat amygdaloidal. Anterior extremity obliquely rounded and angulated at its junction with the dorsal margin; posterior, somewhat acute. Dorsal margin well arched, sinuated in front; ventral, straight or slightly convex towards anterior extremity. Outline seen from above compressed ovate, thickest in the middle. End view sub-spherical.

Length of largest specimen, 1·6 mm.; greatest height, ·9 mm.; thickness of carapace, ·73 mm.

In lateral aspect this species is not unlike *B. Crosskeiana*, Brady,[2] but without the denticuli on the ventral margin. The edge view of our specimens is, however, very different, the greatest thickness being in the middle of the carapace. This species is distinguished by the name of the collector of the specimens which have yielded so many interesting forms.

Found rarely in No. 3,335*b*, *Alveolina*-limestone. Farafra Oasis: Libyan Series.

Bairdia minuta, sp. nov. (Pl. V, Figs. 2*a–c*.)

Carapace compressed; seen from the side sub-trigonal. The anterior extremity rounded at the antero-ventral angle, and slightly sinuate on the opposite or antero-dorsal angle. The posterior extremity is acute and sinuate. The dorsal margin well arched in the middle, the ventral hollowed below the middle. Edge view sub-ovate, but thin; end view sub-oval.

Length, ·9 mm.; height, ·5 mm.; thickness, ·33 mm.

One example of this small but neatly-shaped form found in No. 3,335*b*, *Alveolina*-limestone. Farafra Oasis: Libyan Series.

Cythere farafrensis, sp. nov. (Pl. V, Figs. 3*a–c*.)

Carapace tumid, sub-quadrangular in its lateral aspect; greatest height in front, and equal to nearly two-thirds of the length. The anterior extremity somewhat straight and gently rounded at the

[1] G. S. Brady, 1880: Rep. Chall. Exp., Zool., pt. iii, p. 56, pl. viii, figs. 1*a–f*, 2*a–f*.
[2] Rep. Chall. Exp., Zool., pt. iii, p. 58, pl. ix, figs. 3*a–c*.

angles; posterior extremity narrower and rounder. Dorsal margin nearly straight, slightly incurved at the middle, where the anterior flange tapers off. Ventral margin straight, but in the lateral aspect encroached upon by the postero-ventral swelling. Surface of carapace gradually rising from the antero-dorsal angle toward the postero-ventral, where it is steep, and surmounts the posterior flange; somewhat pitted and having three or more small tubercles arranged in the centre of each valve. Outline, as seen from above, irregularly ovate, widest at the posterior third, the anterior extremity rapidly tapering and concave in that part of the outline; posteriorly the carapace ends in a blunt point. End view suborbicular and slightly wedge-shaped at the dorsal margin.

Length, ·76 mm.; height, ·5 mm.; thickness of carapace, ·53 mm.

From the *Alveolina*-limestone, No. 3,335*b*. Farafra Oasis: Libyan Series.

(*To be continued: the Plates will be given in our next Number.*)

IV.—The Zigzag Course of the Cheddar Gorge.

By C. Callaway, M.A., D.Sc., F.G.S.

HAVING undertaken to explain the geology of the Cheddar gorge to the Cotteswold Naturalists' Field Club at one of their field-meetings this Summer, I thought I should do so more intelligently if I first acquired a practical knowledge of my subject. I accordingly paid a preliminary visit to Cheddar. There were two chief questions to be investigated: (1) the origin of the gorge, and (2) the cause of its serpentine, or rather zigzag, course. The former inquiry had been answered in four different ways. There had been geologists who held that the valley had been excavated by the waves of the sea. A second school taught that it had been produced by a dislocation, splitting the rocks asunder. The third theory regarded it as a valley of erosion, excavated in the ordinary way by a river on the surface. A fourth explanation placed the river underground, and maintained that the glen had originally been a long winding cavern, the roof of which had subsequently fallen in.[1]

Very little investigation was needed to convince me that hypotheses one and two were of no value. My inquiry led me to consider that on the whole the cavern theory was most in accordance with the facts, and I provisionally adopted it in my subsequent exposition to the Club. I confess, however, that with my present knowledge of the locality I am unable to find a decisive preponderance of evidence in its favour, and I leave the question still open. I therefore limit myself in this paper to the second inquiry—the serpentine course of the gorge.

I felt some surprise to find that a stream running down so steep a slope should have described such rapid curves. The floor of the valley at its mouth, near where the underground river emerges at the surface, is 85 feet[2] above sea-level. In half a mile it rises to 340 feet, and in a mile to 500 feet, or a rise of 255 feet in the first half-mile and 160 feet in the second. Just beyond the mile, at

[1] See also Proc. Geol. Assoc., vol. xi, pp. ccvii and 493.

[2] The heights are taken from the 6-inch Ordnance Map.

Black Rock, the elevation is 511 feet, and, less than two miles due north of this point, the highest summit of the Mendips reaches 1,068 feet, or a rise of about 304 feet per mile. The slope in the lower half-mile of the gorge is therefore little less steep than the upper half of the side of the mountain. A stream running down this incline would be a torrent, and we should not expect it to meander rapidly in homogeneous rocks, whether it flowed above ground or below. A special cause of the curving or zigzagging was therefore to be looked for.

It is well known that the Cheddar gorge is excavated in the Carboniferous Limestone, that the strata dip at about 20° to the south or a little to the east of south, and that in a general way the valley runs along the strike, so that on the south side the outcropping strata overhang, and often form lofty cliffs, while on the north the beds slope gently down to the floor of the valley. A stream rushing rapidly along the strike of hard strata might be expected to carve out a tolerably straight course.

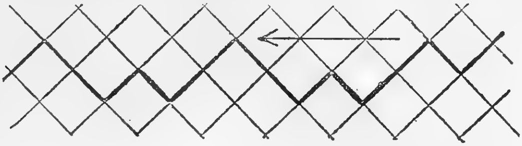
I ascertained that the serpentine course of the valley is caused by the jointing in the limestone. The rock is traversed by two systems of joints, which appear to be vertical or nearly so, intersecting approximately at a right angle. This fact presents itself at almost every turn in the glen. The joint-surfaces are seen to form salient and re-entrant angles, the former opposite the latter, so that if the two sides of the glen were brought together they would seem to interlock. This correspondence has probably given rise to the supposition that the gorge owes its origin to a zigzag rift, followed by a movement asunder of its two sides.

The joints are often closely approximated, so that, in quarrying, the limestone readily breaks away in cubical blocks. But this is not material to the problem. If the joints are not open ones, they will not admit the passage of water, and a rock traversed by them is practically impervious.

That the jointing has caused the zigzags in the glen is apparent, whether the stream flows above ground or below the surface. Take the former alternative. The general direction of the movement would be along the diagonals of the parallelograms made by the joints, for that is the direction of the present slope of the valley, and it is the direction supposed to be taken by the present subterranean river.[1] But the water would soak along open joints, and widen them into fissures, and the flow would be diverted into these fissures. The movement would be sometimes to the right, sometimes to the left; but it would always tend to return to the line of the diagonals. The stream, after flowing for some distance along an open joint or fissure (say) to the right, would be compelled by gravity to seek a passage to the left, and this would be afforded when the next fissure in that direction was reached. The natural course of the current would thus be determined by the open joints, and would follow a zigzag line. The channel thus produced would be gradually enlarged into a valley; but the aerial weathering would act along

[1] Buckland & Conybeare: Trans. Geol. Soc., ser. II, vol. i, pt. 2, p. 223, note.

joints, whether open or concealed, and the zigzag course would be maintained. The following figure illustrates my explanation.



Diagrammatic plan of part of the Cheddar Gorge, showing the rectangular jointing, the open joints followed by the stream being indicated by the thick lines. The arrow shows the direction of the slope.

The theory I have here expounded will apply still more aptly to the second alternative—that the valley was excavated by an underground river. Such a stream *must* have followed joints, for they are the only conceivable channels, and a succession of zigzags is the only form which the gorge could assume.

But it may be objected that the course of the stream which carved out the Cheddar glen was probably determined in an overlying formation, Cretaceous or Jurassic. Let us inquire how this hypothesis will work. Such a river flowed over a surface of Chalk or other Mesozoic sediment. Vertically above the line of the present glen it must *ex hypothesi* have described the same zigzags. It cut its way down lower and lower until it flowed over a surface of Carboniferous Limestone, and then it was found that the lines of the zigzags were parallel with the joints in the limestone. Such a coincidence is perhaps credible, but it demands the exercise of greater faith than my nature is able to command.

There is a second improbability in this hypothesis. Why do the zigzags stop at the mouth of the gorge? On my theory, this ought to be the case, because it is here that the limestone ends and the Trias comes in. But if the course of the river which excavated the valley had been determined on a Mesozoic surface, the rapid meanders would have been continued further on to the south-west. We find, on the contrary, that when the present river leaves the limestone, and passes on to the Trias, its course becomes less serpentine. Yet in its journey of half a mile over the Trias it falls only 25 feet. It follows from this that as the river cut its way down to lower levels, its course south-west of the limestone became less and less steep, and its flow less rapid. It ought, therefore, according to the known laws of river action, to have become *more* serpentine below the limestone. As the opposite effect has resulted, we are driven to conclude that there was something in the limestone itself, irrespective of the windings of the river on its Cretaceous or Jurassic surface, which determined the present zigzag shape of the glen.

Whether the river that formed the gorge originated on or in the limestone on the one hand, or on a higher Mesozoic surface on the other, appears to be not very material. In the latter case, it is to me incredible that the old curves should be maintained in a rock traversed by joints, many of which the solvent action of river-water must have quickly converted into fissures.

V.—On a new Trilobite from the *Dictyonema*-shales of the Malvern Hills.

By Professor Theodore T. Groom, M.A., D.Sc., F.G.S.

Acanthopleurella Grindrodi, gen. et sp. nov.

In the collection made by the late Dr. Grindrod, now in the Geological Museum at Oxford, there is a minute species of trilobite, represented by two specimens, obtained from the *Dictyonema*-shales of the Malverns. This form was referred by Dr. Callaway to *Shumardia* (*Conophrys*) *Salopiensis*, Call.;[1] but a careful study of the two specimens, aided by the removal of a small fragment of shale which partly concealed the more complete example, has shown the distinctness of the trilobite from *Shumardia*, and from any other genus known to the writer. Owing to the kindness of Professor Sollas I have been enabled to make a thorough examination of the specimens. The preservation is fairly good, but much of the actual test has been lost, and both fossils are largely in the form of internal casts. In the more complete but somewhat smaller example, which may be taken as the type-specimen, the whole trilobite is preserved (Fig. 3); in the second specimen little more than the thorax and pygidium is seen (Fig. 4). The following description refers to the type-specimen:—

Head smooth, semi-elliptical; frontal and lateral margins descending somewhat suddenly; genal angles acute. Glabella fairly convex, smooth, broad in front, reaching the margin (which here projects slightly beyond the cheeks), rather more than one-third of which it occupies; narrowing rapidly behind to the neck-furrow, behind which it expands again to form a well-pronounced and rather broad neck-lobe; separated from the smooth cheek by a deep and fairly broad axal furrow with a rounded floor; neck-furrow not strongly marked on the glabella, but well-pronounced on the free cheeks, to the posterior margin of which it is parallel; on the inner side it unites with the axal furrow, and on the outer extends nearly to the genal angle, and much resembles one of the pleural furrows; cheeks in front of the neck-furrow rising up steeply to their greatest height; no traces visible of other furrows on the glabella, or of eyes, or facial sutures on the cheeks. Length of head, 0·41 millimeter; breadth, 1·12 millimeter.

Thorax slightly narrower than the head, and longer than either head or pygidium; consisting of four segments. Axis very convex (Fig. 2), occupying some two-fifths of the width of the thorax in front, and gradually diminishing in breadth behind; inflated in each segment, the inflated portions being separated by rounded depressions, and extending to the pleuræ in the form of ridges directed obliquely forwards, one on each side. Pleuræ straight for most of their length, depressed near the axis (Fig. 2), especially in the first rings of the thorax, the depression gradually

[1] Quart. Journ. Geol. Soc., 1877, vol. xxxiii, p. 660.

dying out behind; each pleura facetted in front, and marked by fairly deep, straight grooves for the whole of their length, the grooves being margined in front by a well-defined ridge; at their ends the pleuræ suddenly bend sharply backwards and a little downwards, and end in spines; traces only of the first three pairs of spines are seen, but those of the fourth segment are long and extend for some distance behind the end of the pygidium. Length of the thorax, 0·54 millimeter; breadth, 1·08 millimeter.

Fig 1.

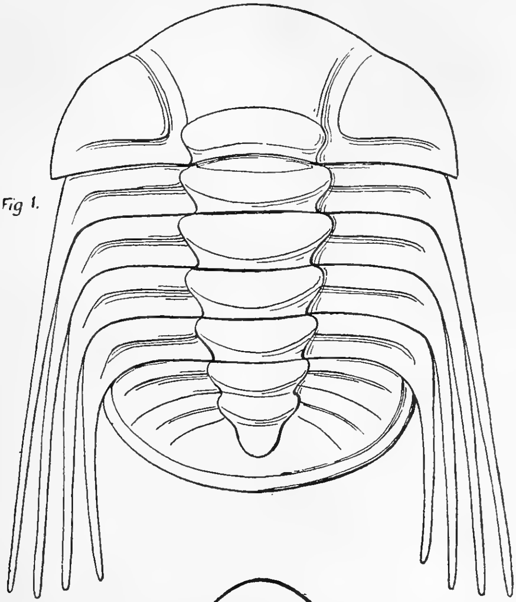


Fig 2

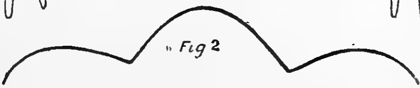


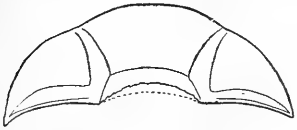
FIG. 1.—*Acanthopleurella Grindrodi*, gen. et sp. nov., restored with the aid of the specimens shown in Figs. 3 and 4. The spines at the ends of the pleuræ of the first three rings of the thorax require very careful illumination to render them visible.

FIG. 2.—Optical section of the tergum of the thorax of the specimen shown in Fig. 3.

Pygidium semi-elliptical; axis convex, conical, terminating at a short distance in front of the hind margin, and showing only one well-marked transverse constriction. Limbs tolerably flat, with several ridges and grooves corresponding to those of the thoracic pleuræ, and extending as far as the raised marginal rims. Margin probably entire. Anterior angles apparently rounded. Length of pygidium, about 0·4 millimeter; breadth, 0·83 millimeter.

The specimen is partly enrolled; this fact, together with its convexity, has made it impossible to obtain good photographs of the whole trilobite. The total length when unrolled would be 1·4 millimeter, or two-thirds of a line.

The second specimen (Fig. 4) belongs to an individual somewhat larger than the first. The length and breadth of the thorax are 0·62 and 1·1 millimeter respectively, and those of the pygidium 0·35 and 0·85 millimeter. The specimen, moreover, is less convex, perhaps partly owing to pressure, and the axis of the thorax is broader; in front it occupies nearly one-half of the total breadth of the thorax, and behind about one-third of the breadth at that point. The ridges connecting the axes with the pleuræ are, moreover, broader. Apart from these differences in proportion the two specimens agree, but the details of the thorax and pygidium are better shown in the second specimen. The spines of the first three thoracic rings are more perfectly shown, and those, at any rate, of the second and third extend backwards for a considerable distance. The pygidium shows more definite indications of a composition out of two segments in front, and an obscurely segmented or unsegmented portion behind; the rather narrow raised margin of the limbs is very distinct, and is entire. The anterior angles appear to be rounded. Of the head little more than a part of the neck-segment is preserved.



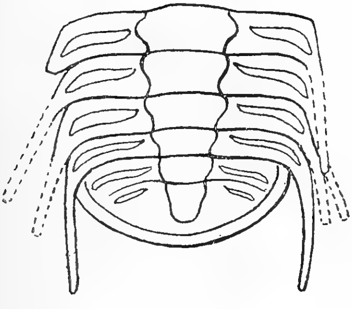


FIG. 3.

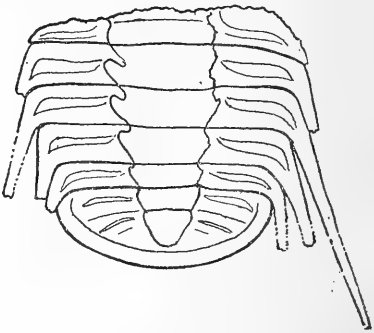


FIG. 4.

FIG. 3.—Head, thorax, and pygidium of *Acanthopleurella Grindrodi*, gen. et sp. nov., × 37, as made out with the aid of photographs and drawings. The specimen being partly enrolled, all three parts have been drawn separately.

FIG. 4.—Thorax, pygidium, and a portion of the head of *Acanthopleurella Grindrodi*, gen. et sp. nov. × 31. The outlines of this figure were traced from a photograph, with the exception of the portions defined by dotted lines, which have been made from freehand and camera lucida sketches.

Both specimens were obtained from the grey shales of the Southern Malverns, in which also *Cheirurus Frederici*, Salter, *Agnostus dux*, Call., and certain imperfect Asaphids and Olenids have been found. These probably include *Platypeltis Croftii*, Call., *Asaphellus affinis*, McCoy, *Niobe Homfrayi*, Salter, *Niobe*, sp., and *Parabolinella*? *triarthrus*, Call.

The affinities of this little trilobite are obscure. The diminutive size, the small number of segments, and the apparent absence of eyes and facial sutures suggest that it may be a larval form. On the other hand, these features are also shown by such minute trilobites as *Agnostus*, *Microdiscus*, and *Shumardia*; and the lack of resemblance to any of the larger trilobites of the Tremadoc fauna, together with the circumstances that both specimens are minute, and that the larger of the two shows no advance in organization, tells in favour of the view that we are dealing with an adult form. For this form I would suggest the name of *Acanthopleurella Grindrodi.* The conformation of the head suggests Trinucleoid affinities, but there is no marginal rim, and the rest of the body appears to show Olenid characters. *Shumardia* is possibly an ally, but from this form *Acanthopleurella* differs in the extension of the glabella to the front margin of the head, in the absence of all glabella-furrows with the exception of the neck-furrow, and in the spinous prolongations of the thoracic pleuræ, and in other respects.

NOTICES OF MEMOIRS.

I.—On a Primitive Type of Structure in Calamites. By D. H. Scott, M.A., Ph.D., F.R.S.[1]

PALÆONTOLOGICAL research has afforded evidence that the Horsetails and Lycopods, groups now so distinct, had a common origin. The class Sphenophyllales, restricted, so far as we know, to the Palæozoic epoch, combines in an unmistakable manner the characters of Equisetales and Lycopodiales, while at the same time presenting peculiar features of its own. Broadly speaking, it is in the external morphology and in the reproductive structures that the Equisetales are approached, while the anatomy has an evidently Lycopodiaceous character.

The synthetic nature of the Sphenophyllales, indicated clearly enough in the type-genus *Sphenophyllum* itself, comes out still more obviously in the new genus *Cheirostrobus*. Here the general morphology of the strobilus, the form and structure of the sporangiophores and of the sporangia themselves, are all of a Calamarian type, while the anatomy of the axis is as clearly Lycopodiaceous in character.

So far nothing has been found to bridge the gulf which separates the anatomy of the Calamarieæ (Palæozoic Equisetales) from that of the Sphenophyllales or the Lycopods. The most ancient known genus of Calamarieæ—*Archæocalamites*—approaches the Sphenophyllales in the superposition of the foliar whorls and in the dichotomous subdivision of the leaves, points on which Professor Potonié, especially, has laid stress. Anatomically, however, according to the researches of Dr. Renault and Count Solms-Laubach, it was an ordinary Calamite, differing in no essential respect from those of the Coal-measures. The stem of *Archæocalamites*, like that of its later allies, had a large pith, surrounded by a ring of collateral vascular bundles, the wood of which, primary as well as secondary,

[1] Read before the British Association, Section C (Geology), Glasgow, Sept., 1901.

was wholly *centrifugal* in development, the first-formed tracheides lying on the border of the pith, at the points marked by the carinal canals. In *Sphenophyllum*, on the one hand, the whole of the primary wood was *centripetally* developed, and there was no pith. In *Cheirostrobus* the same holds good, except that an insignificant portion of the primary wood may possibly have been added in a centrifugal direction. In Lycopods there may or may not be a pith, but the whole (*Lycopodium, Psilotum, Lepidodendron*) or the greater part (*Tmesipteris*) of the primary wood is centripetal.

The Calamite which forms the subject of the present communication occurs in the well-known Burntisland beds of the Calciferous Sandstone Series, at the base of the Carboniferous formation. The material is calcified, and the structure excellently preserved, though the specimens so far discovered are small and fragmentary. Their interest depends on the fact that each vascular bundle possesses a distinct arc of centripetal wood on the side towards the pith. The carinal canals are present, as in an ordinary Calamite, and contain, as usual, the remains of the disorganized protoxylem. They do not, however, as in other Equisetales, form the inner limit of the wood, but xylem of a considerable thickness, and consisting of typical tracheides, extends into the pith on the inner side of the canal, which is thus completely enclosed by the wood. Hence, starting from the spiral tracheides of the protoxylem, there was here a considerable development of xylem in a centripetal as well as in a centrifugal direction. That the organ was a stem, and not a root, is proved, not only by the presence of the carinal canals, but by the occurrence of nodes, at which the outgoing leaf-traces are clearly seen.

This appears to be the first case of centripetal wood observed in a Calamarian stem, and thus serves to furnish a new link between the Palæozoic Equisetales and the Spenophyllales, and through them with the Lycopods.

The specimens have not as yet supplied any evidence as to the superposition or alternation of the verticils, so we are not at present in a position to determine the genus to which they belonged. Provisionally, until further investigation has cleared up this question, the new stem may bear the name of *Calamites pettycurensis*, from the locality where it occurs.

II.—The Scottish Ores of Copper in their Geological Relations. By J. G. Goodchild, F.G.S.[1]

THE ores of copper occurring in Scotland appear, so far as their origin is concerned, to be referable to two primary categories. The first of these includes those minerals whose origin is evidently connected with the uprise of thermal waters; and the second includes those which are due almost entirely to deposition of materials carried down in solution from some rocks at a higher level to others below. The two methods of origin may be likened to the ebb and the flow of the tides.

[1] Read before the British Association, Section C (Geology), Glasgow, Sept., 1901.

To the first category belongs most of the Chalcopyrites occurring in Scotland, and with that mineral is to be included also Chalcocite and Bornite. These mostly occur in connection with mineral veins. A small percentage of other compounds of Copper with Sulphur appears to have originated in connection with certain eruptive rock of sub-basic composition. When these latter have been affected by dynamic metamorphism the process seems to have favoured the local concentration of the mineral which was formerly diffused. Hence several Epidiorites contain Chalcopyrites, apparently as an original constituent (if we regard their schistosity as original to that type of rock).

To the second category, that of the ebb-products, or minerals of secondary origin, belong all the remainder.

Taking these in the order, and with the numbers, adopted by Dana, we have, first, (15) Native Copper. There cannot be much doubt that all the Scottish specimens of this are of secondary origin. The earlier stage seems to have been that of solution, along with those of the constituents of a sub-basic eruptive rock, through which, probably, the copper ore was originally diffused in very minute quantities. The decomposition of the rock by surface agencies has again converted this into solution—probably in the form of carbonate —from which solution any one of various reagents, in most cases probably decomposing organic matter, has reduced the dissolved substance to the metallic state. In this form it has been deposited as thin sheets along the divisional planes of the rocks situated at a lower level than its point of origin. In the form of films of this kind it occurs at Boyleston, in Renfrewshire, where it is found in lavas of Lower Carboniferous age; and at Ballochmyle, in the joints traversing the marls of the New Red Rocks there. I may remark, in passing, that these rocks so closely resemble the Bunter Sandstone that I should never have hesitated to refer them to that horizon had not a different opinion regarding their age been expressed by the distinguished author of "The Scenery of Scotland."

Native Copper also occurs in the form of minute particles—possibly crystals—in some of the Prehnites of Boyleston and Glen Farg. Doubtless these varieties of Prehnite owe their colouring matter to the presence of this mineral, just as the ordinary green variety of Prehnite owes its colour to diffused compounds of copper of other kinds—possibly to Chrysocolla. The same metal also occurs at Boyleston, disseminated throughout some of the beautiful crystals of Calcite which line some of the drusy cavities of the lavas there. When Native Copper is enclosed in these crystals the external form is much more complex than where the metal is absent.

Some Chalcopyrites must undoubtedly be classed amongst ebb-products also, seeing that a second generation of crystals often occurs upon minerals whose secondary origin cannot be doubted. Atacamite has been claimed as a Scottish mineral, but, it seems to me, on insufficient grounds.

(224) Cuprite, as might be expected, occurs in connection with the other decomposition products of common ores. Usually it occurs

as one of the constituents in the compound known as Tile Ore: but occasionally, as at Glen Farg, it shows traces of crystalline exterior; or as at Boyleston, where Mr. Craig-Christie has got it in the capillary or velvet-like form. Some of the silicate of copper from Lauchentyre appears to me to be coloured red by Cuprite, which may also occur there in the free state.

(230) Tenorite has not yet been proved to occur as a separate Scottish mineral; but the black Chrysocolla from Lauchentyre and other mines in the neighbourhood may possibly owe its coloration to this mineral.

(288) Malachite calls for no special remark here beyond the statement that it does not appear to show crystalline termination at any locality in Scotland except at Sandlodge, in Shetland, where it seems to have been taken for Brochantite.

(289) Azurite is singularly rare in Scotland, and has not yet been found with visible crystalline faces. (290) Aurichalcite, (741) Linarite, and (739) Caledonite, well known as secondary products of the decomposition of veins containing Copper, do not call for any special remark in this abstract.

REVIEWS.

I.—Roads: their Construction and Maintenance; with Special Reference to Road Materials. By Allan Greenwell, Assoc. M. Inst. C. E., F.G.S., and J. V. Elsden, B.Sc., F.G.S. 8vo; pp. 280. (London: *The Builder* Student's Series. Price 5*s*.)

GEOLOGISTS may well claim to have an interest in road-metal. The heaps of stone by the roadside arrested the attention of the 'naturalists' in old days, and ofttimes attracted them to the quarries. Thus the Kellaways Rock of Wiltshire came into notice and attained a distinction which nowadays would not have been accorded to it. Then each parish, whenever possible, provided material for its roads, and in different parts of the country there were numberless pits and quarries, many of which have long since been closed and hidden beneath soil and vegetation. Even now many by-roads are mended with local stone of no great durability, and in parts of Somerset these ways are repaired with the basement limestones and fossils of the Upper Lias. Along the principal roads the freestones and rag-beds of the Oolites, however, are less frequently used; the Carboniferous Limestone, the Hartshill stone, and the dark basalts of Clee Hill and Rowley Regis have usurped their place. Far better roads have resulted, although carriers have complained that they cannot see their way at night so readily as of yore on the present dark metal. To the introduction of railways we may trace the dispersal of the better kinds of road material, while, as the authors remark in the work before us, the powers acquired by County and District Councils "have completely revolutionised the system of road management in this country."

Arranging their subject under three heads—(1) Materials, (2) Construction, and (3) Maintenance—the authors in the first part deal with the selection of road material, and point out the various kinds of rock that have been used, and their geological distribution. Figures of micro-sections are given to make clear the mineral structure of various kinds of stone; while their texture and absorptive power and the joints in the rocks are duly explained. Special tables are given of the principal constituents of some igneous rocks used as road stone.

The value of particular stones as paving setts is pointed out, and it is observed that some igneous rocks wear to a smooth and slippery surface. Following the igneous rocks, the sandstones, limestones, flint and chert, and gravel are successively dealt with. There are also chapters on artificial materials, including slag, which is extensively used in some neighbourhoods, though it yields an offensive odour and is unsuitable for residential areas. Among paving materials, wood and asphalt are included.

Tables showing results of various tests are given in reference to some of the principal rocks, and in the 'percussion test' we note that the greenstone of Penzance withstood the greatest number of blows. This is evidently the well-known Penlee stone, which is elsewhere referred to under that name, and also as Newlyn stone. After considering various tests of strength it is well observed that the test of experience is the best; but this is not always forthcoming.

In the second part of their work the authors give a brief historical account of roads from Roman and mediæval times to the days of Macadam and Telford. A knowledge of geology is of essential service in the laying out and construction of roads. Cyclists in particular are shrewd observers of roads, and with a knowledge of geology they may, as Mr. F. J. Bennett has pointed out, learn much from the gradients, the springs, and the character of the surface formed by the road-metal.[1] The very diversity is interesting, and we should not wish to see Telford's rule adopted that "It is absolutely necessary to remove trees from the sides of roads, and to keep the fences under five feet in height."

The authors give numerous illustrations, some geological, to aid in their explanations of road-making. Indeed, in this and other respects the accumulated knowledge of the engineer and the practical geologist is happily combined in this volume. Thus the work, though professedly of an elementary nature, should prove most useful to local road-surveyors and to others called upon to find or advise in selecting road material.

A fuller index than the authors have given would be desirable in a new edition; thus, Crushing strength, Cobbles, Mountain Limestone, Oolite, Forest Marble, Greywethers, and a few other subjects referred to in the text, should have been found. Mention is made of certain tests of rocks carried out in Maryland, and the reference might have been given to the third volume recently

[1] "Influence of Geology on the Early Settlements and Roads": Proc. Geol. Assoc., vol. x, p. 377.

published by the Maryland Geological Survey, which contains an exhaustive account of the highways, their history, relations to topography, climate, geology, and various other matters, and is a handsomely illustrated volume.

H. B. W.

II.—The Riddle of the Universe at the Close of the Nineteenth Century. By Ernst Haeckel, Ph.D., M.D., LL.D., Sc.D., Professor at the University at Jena. 2nd edition; pp. 398. Translated by J. McCabe. (London: Watts & Co. Issued by the Rationalist Press Association, Ltd., 1901.)

In "Die Welt-räthsel," most ably translated by Mr. J. McCabe, Professor Haeckel presents the "continuation, confirmation, and integration" of his views on the monistic philosophy already expressed in previous volumes and in a paper read at the Fourth International Congress of Zoology at Cambridge in 1898. He claims that, after working at it for half a century, his system is now mature, and offers a full explanation of the phenomena of nature, as well as a solution of the "conflict between Science and Religion"—in short, that it solves the "Riddle of the Universe."

He argues that, while our scientists have made, during the past century, extraordinary progress in the unravelling of the mysteries of the universe, they have been too much bound down by specialism, and have not sufficiently studied the universal connection of the phenomena they observe. In consequence of this, advantage has not been taken of our increased knowledge, and no corresponding improvement is to be observed in our systems of government, of administrative justice, of national education whether in the school or from the pulpit, of social and moral organization. We may congratulate ourselves that here, in Britain, we are exempt from at least some of the defects mentioned by Professor Haeckel under these headings.

The author's solution of the difficulty is that a change should be made in the present system of education. The study of nature, combined with the elements of evolutionary science, should take the first place. Let the child be taught a correct view of the world he lives in, and be given an insight into the natural connection of all phenomena, as, indeed, Huxley advocated in his science of physiography. Let him understand that reason alone, itself the result of the development of knowledge, can unravel the mysteries of life, and that no cosmic problem can ever be solved by emotion. This development of the use of reason by education and experience would, the Professor thinks, lead to the universal adoption of 'Monism' as the true solvent of all cosmical and religious difficulties.

Monism, in its widest sense, recognizes one sole law in the universe, the *Law of Substance*, which embraces conservation of matter and conservation of energy. The monist holds that the universe is at once "God and Nature," and, with Spinoza, that body and spirit (or matter and energy) are inseparable. Sensitive and thinking substance are the two fundamental attributes of the all-embracing divine essence of the world, the universal substance. Opposed to Monism is Dualism, which, in its widest sense, breaks up the universe into two entirely distinct substances—the material world, and an immaterial, extramundane God. Dualism necessarily leads to Theism, in some form. Monism, on the other hand, leads to Pantheism, which teaches that God is everywhere identical with Nature itself.

Whether or not we adopt Professor Haeckel's views on religious matters, the book is well worth reading as a resumé of the progress of the various branches of scientific knowledge to the end of the nineteenth century, and particularly, as we should expect from the author, of biology. The subject of the "conflict between Science and Religion" holds a conspicuous place in the argument. It has already been well handled by Strauss, Feuerbach, and Draper, to whom Haeckel refers his readers. For geologists, the best account of the part which geology has played in the controversy is that given in the magnificent work of Mr. A. D. White, who points out that the contest is *not* between Science and Religion, but between Science and dogmatic theology, of whatever kind.

J. A. W.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—December 18th, 1901.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair.

Professor H. G. Seeley drew attention to a skull of *Equus fossilis* from Keswick, exhibited by Mr. J. Postlethwaite, F.G.S., and said that it belonged to a species of horse, but the skull appeared to be broader and flatter in front of the orbits than in *Equus caballus*; and it gave evidence on the upper surface of being an aged specimen, an inference which was supported by the palatal conditions. The teeth are worn down, so as to approximate to the condition of aged teeth of *Equus fossilis*, as sometimes met with in river-valley gravels; but he was not aware that these teeth had previously been met with in association with this form of skull. He understood that the specimen had been found near the surface beneath an ancient building at Keswick, and that there was no evidence as to its geological antiquity.

Professor W. W. Watts called attention to a set of twenty-two photographs, the first of three sets to be published as typical examples of geological photographs by the Committee of the British Association on Geological Photographs.

The following communications were read:—

1. "Coal and Petroleum Deposits in European Turkey." By Lieut.-Colonel Thomas English, F.G.S.

In this paper an account is given of the formations which include some recently discovered coal-seams and naphtha-bearing sands of Tertiary age in the little visited stretch of country lying to the north of the Gulf of Xeros in the Mediterranean, and of the western portion of the Sea of Marmora. The geological map which accompanies the paper is founded on the topography of that compiled by the Russian military staff. The lowest beds seen are soft brown limestones, with nummulites of Lutetian age, overlain by blue shales. These, again, are covered conformably by brownish-grey calcareous sandstones, with subordinate beds of clay and shale, and occasional interruptions of basalt and rhyolite, which are folded into a well-marked syncline and anticline. In these sandstones there are outcrops of several seams of coal, one being 3½ feet thick. It is a bituminous, hard, non-coking steam-coal, with a sandstone floor and hard clay-roof containing impressions of dicotyledonous leaves. Associated with the coal is a layer of brecciated rhyolite, which may have had some influence in converting lignite into true coal. The section of a trial boring, striking the coal at 122 feet from the surface, is given; and also that of a boring 225 feet deep immediately below the coal. Apparently overlying the sandstones are palagonite-tuffs, shales, and hard limestones of Miocene age. The Eocene sandstones are occasionally overlain by soft sandy strata, probably Pliocene, with which naphtha-bearing beds are interstratified. Naphtha in quantity, under considerable gas-pressure, has been obtained from borings, a section of one of which is given, 300 feet deep. The strata are much disturbed and are nearly vertical in places. A stony clay, having no apparent connection with the present drainage system, and containing scratched, striated, and facetted boulders, spreads unconformably over all the formations previously mentioned. At the Hora lighthouse a well-marked 'raised beach' occurs at 130 feet above present sea-level, sometimes cemented into a concrete, in which occur *Dreissena polymorpha* and a *Neritina*, probably *N. danubialis.* The fresh water within the Sea of Marmora must at this epoch have stood at a height sufficient to collect the drainage of the whole of South-Eastern Europe and Western Asia, an area of at least 2,000,000 square miles, into a freshwater sea, from which the volume of water discharged (even with the present small rainfall) would be not less than twice that of Niagara. The Dardanelles channel is itself a gorge cut back through soft horizontal Miocene strata, with every appearance of rapid erosion by falling water.

2. "On the Geological and Physical Development of Dominica; with Notes on Martinique, St. Lucia, St. Vincent, and the Grenadines." By Professor J. W. W. Spencer, Ph.D., M.A., F.G.S.

These islands form a continuation of the volcanic chain extending from Guadeloupe, though separated one from the other by embayments in the submarine plateau, reaching to depths of more than 6,000 feet, within the line connecting the shores of the islands. These submarine valleys head in cirques, like the amphitheatres which occur on the slopes descending from high plateaux. From the ends of the cirques, valley-like channels can be traced landward on the submerged plateaux, or can be found to cross them in order to join like features on the other side. The cols between the opposite valleys vary in depth from about 2,000 to 3,600 feet, except that between the Grenadines and the Trinidad banks, where the divide may not be more than 750 feet below the surface of the sea, and one south of St. Vincent (less than 1,300 feet). Some of the submarine channels have remarkable tributaries. The drowned valleys, like those about the islands to the north, assume two very different forms—those with broad undulating outlines, such as characterize the features produced during the long Miocene-Pliocene period of erosion, when the surfaces of the land were at or near the base-level of erosion, and other types where very deep valleys and gorges incise the more rounded features of the drowned plateau, which in the early Pleistocene epoch thus appears to have stood for a limited time at an altitude of 6,000 or 7,000 feet, as shown within the limits of the Antillean mass (and still higher from evidence beyond). There are no coastal plains, strictly speaking; only to a very limited extent are the islands surrounded by shelves submerged to a depth of less than 200 feet. But the Grenadine banks are extensive. One or two outlying remnants of the Antillean plateau occur south-east of Dominica, and another about 60 miles east of Martinique, all of which may be fragments of the old coastal plains.

All the islands are underlaid by old Tertiary or pre-Tertiary igneous rocks, as in Guadeloupe. Such, where exposed, are found to be very much decayed. Elsewhere, they are covered by tuffs with only angular breccia. Upon such surfaces, denuded, rest other tuffs derived from older deposits, containing water-worn pebbles, in lines of bedding. These last may be the equivalent of the Tertiary tuffs and limestones of Guadeloupe. Upon their eroded surface rests a gravel formation, which itself has largely been washed away. In the hollows of its surface is found another formation composed of coral limestone, containing a fauna which still survives, with one or two possibly extinct forms. The deposit occupies a position similar to one in Guadeloupe and another in St. Kitts. Its surface is also greatly eroded, and then covered with another stratified sand-and-gravel accumulation. The surface of the slopes is often covered by a loam, which, in part at least, is a land-formation. The Pleistocene Period is thus seen to have been one of changing physical conditions. The older Tertiary history must be inferred from that of the neighbouring islands.

Lavas may be seen underlying the gravels, and accordingly we find that the volcanic activity was renewed, after a very long Tertiary quiescence, in the Pleistocene Period.

The plains underlaid by the beds of old tuffs have been so raised up as to give rise to sloping terraces dipping outward from the late volcanic centres, showing that their elevation has been due to local uplifts, and not to regional movements, and also that to igneous centres alone are confined the volcanic uplifts, which do not extend to such remnants of coastal plains as are found in the Antillean region. The recent terraces, which are not deformed, are small, and perhaps do not rise to more than 70 feet above the sea. Youthful cañons are being formed near the mouths of the streams, showing the recent re-elevation of the land.

3. "On the Geological and Physical Development of Barbados, with Notes on Trinidad." By Professor J. W. W. Spencer, Ph.D., M.A., F.G.S.

Barbados, over 100 miles east of the main chain of islands, is a remnant of the dismembered and sunken Antillean plateau, with the embayment in it, west of the islands, reaching to a depth of over 7,000 feet. But the drowned Barbados ridge extends far, both to the south and to the north of the island, and is connected by another ridge with the Martinique mass. Its hydrographic features are best understood when studying the question of the general relationship of the islands.

Trinidad is part of the South American continent, being on the subcoastal shelf which extends much farther seaward.

The Scotland Sands and the deep Oceanic Series of Barbados have been comprehensively studied by others. The Oceanic Series is here shown to be no newer than the Eocene Period, and the Scotland Series is supposed to date back to the beginning of the Tertiary or even to an older epoch. The 'Raised Coral-Reefs' are differentiated into three formations, all of white limestone or marl. The oldest beds are all tilted to considerable angles. They contain an Oligocene fauna. Their surfaces are eroded into rounded forms, showing that the topographic feature was completed at a low elevation above the base-level of erosion. As no other Tertiary formation occurs until the close of the Pliocene, it is inferred that the region was a land-surface throughout the long Miocene-Pliocene Period. This limestone is the equivalent of the Antigua formation. In the hollows of its surface occur the remains of a mechanical limestone (the Ragged Point Series), which has been mostly carried away by subsequent denudation. It lies in a horizontal position. Newer still is the Bath Series, or raised coral-reefs, with a fauna still living. However, it is an old Pleistocene formation, and its surface is very much denuded. Some of the newer fossiliferous beds may represent even another distinct Pleistocene epoch. The greatest elevation and denudation appear to have been in the early Pleistocene days. The terraces occur in Barbados at much higher elevations than in the other islands, as this district does not appear to have undergone so great an amount of recent subsidence as that which carried down the surfaces, with little cañons and channels, below sea-level, adjacent to the other islands. The local features of Barbados extend our knowledge of the history of the whole chain of islands, besides agreeing with the phenomena found elsewhere.

Trinidad has more continental features than the other islands. Its surface topography has been found to owe its origin to the erosion features of the Miocene-Pliocene Period, which have been covered by only thin mantles as in Barbados, so that its life-history falls into harmony with that of the other islands. In its older beds it has the deep oceanic oozes as in Barbados. No volcanic phenomena have been added to the features of these islands.

II.—January 8th, 1902.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "A System of Glacier-Lakes in the Cleveland Hills." By Percy F. Kendall, Esq., F.G.S., Lecturer in Geology at the Yorkshire College, Leeds.

After referring to existing 'extra-morainic' lakes, such as the Märjelen See and those of the Chaix Hills, the author proceeds to deal with the criteria for the recognition of such lakes. These include beaches, deltas, floor-deposits, and overflow-channels. Shore-scarps are common in Cleveland, but beaches are rare or absent, the reason being in part that stability was rarely secured owing to the overflows being over soft Jurassic strata. Deltas also are not common. The floor-deposit of lakes may be distinguished from river-alluvia by the fact that the lamination is close and regular, but, being parallel to the subjacent surface, it may be highly inclined. On the other hand, alluvia are laid down on horizontal surfaces, but rarely show good lamination. Overflow-channels are grouped into four main types: 'direct overflows,' which trench the main watershed of a country; 'severed spurs,' across the spurs of the main watershed; 'marginal overflows,' at first merely a shelf cut in the hillside, but subsequently developed into an actual gorge; and 'in-and-out channels,' or crescentic valleys excavated in the face of a hill by water flowing round a lobe of ice. Such overflows are independent of the natural drainage; they have at first a slight and then a steep fall, and in section they have steep sides and flat floors. The meanders of the valleys and the run of the contouring also possess special features, and the valleys rarely or never receive any considerable tributaries.

Evidence from borings and drift-filled channels is given to show that during or before the Glacial Period the land was considerably above its present level. The Glacial deposits are described in detail from sections and borings, some of them carried out by the author, and the assemblages of boulders are identified and classified into three chief groups—a Western group, from the Solway, Vale of Eden, Stainmoor Pass, and the Tees; a Northern group, from the Tweed and Cheviots and from Eastern Durham; and an Eastern group, from the Christiania region, the Gulf of Bothnia, and Denmark or the North Sea.

The author has been unable to detect any signs of the presence of the sea in this area at any time during the Glacial Period. Three main ice-masses appear to have been concerned in producing the deposits: one from the Southern Uplands and the Solway, joined by the local ice of the Tees; a second originating in the

Tweed Valley, and driven southward round the Cheviots by the pressure of the third, or Scandinavian, ice-mass. The general order of events is supposed to have been—(1) the unobstructed passage of the Teesdale glacier to the coast; (2) the arrival of the Scandinavian ice; and (3) the invasion of the Scottish ice.

The first of the extra-morainic lakes described is that of the Vale of Pickering, the lowest of the sequence, which for a long period received all the drainage of the district except that of the western margin, and the outflow from which into Lake Humber was that now occupied by the River Derwent. Newton Dale was the outflow of the lake-series of the Eskdale country. The Eskdale system comprises a series of lakes connected by an 'aligned sequence' of overflows; and here it is possible to trace the consequences of the shrinkage of the ice-masses and to follow out the low-level phases of the lake. The ice pressing upon the northern face of the Cleveland Hills gave rise to a series of lakelets, connected with which are the following set of overflows:—Scugdale and Scarth Nick, Bilsdale, Kildale, Ewe Crag Beck, Tranmire, and Egton Moor. Iburndale contained a lakelet overflowing eastward. Behind a narrow coast-strip of country, extending from Robin Hood's Bay to Hunmanby, there runs a gorge which receives all the drainage of the 'hinterland' and carries it into the Vale of Pickering. In the production of this arrangement the effects of an ice-sheet shutting the seaward ends of the valleys is traceable; the position of the main overflows was stable, and the drainage was permanently deflected.

In dealing with the sequence of the ice-movements, evidence is brought forward to prove that the Teesdale ice was the first on the ground in question, but none of the lake phenomena have been correlated with this first phase. The second phase was the complete diversion of this ice into the Vale of York, brought about by the growth of the Scandinavian ice-sheet. The third is the invasion of Scottish-Northumbrian ice, which may have passed out to sea and been driven inland again, carrying flints and smashed sea-shells with it, and may have extended as far as Lincolnshire on the south and Whorlton on the west.

2. "The Glaciation of Teesdale, Weardale, and the Tyne Valley, and their Tributary Valleys." By Arthur R. Dwerryhouse, Esq., B.Sc., F.G.S.

After an account of the topographical solid geology of Teesdale, the author describes the four distinct types of Drift in the area as follows:—

(*a*) A sandy reddish-brown clay, with a large number of well-scratched stones.
(*b*) A black loamy or peaty clay.
(*c*) A coarse gravelly deposit, with many water-worn and a few scratched stones.
(*d*) A stiff blue Boulder-clay.

The first class is the most widely distributed; it occurs in elongated ridges, and is the direct product of ice-action on the rocks of the upper part of the Dale. The black loamy clay is characteristic of areas occupied by ice-dammed lakes. The third class occurs in long esker-like ridges, and is particularly plentiful in the country formerly occupied by the Stainmoor glacier. The dark-blue clay is mainly derived from Carboniferous rocks. A detailed description of the Glacial deposits, boulders, and striæ is next given; and from this the following conclusions are deduced:—Upper Teesdale was heavily glaciated by local ice from the eastern slope of the Cross Fell Range; this part of the Dale was not invaded by any other ice, and the higher peaks stood out as nunataks. At the period of maximum glaciation a number of lakes were formed, owing to the obstruction of the drainage of lateral tributary valleys by the ice of the main glaciers. Lunedale was occupied by ice (the Stainmoor glacier) which came from the drainage-basin of the Irish Sea, joined the Teesdale glacier about Middleton-in-Teesdale, and by its thrust deflected the Teesdale ice into the Valley of the Wear. During the retreat of the ice there was a lengthened period of 'constant-level,' when well-marked drainage-channels were formed, and after this the ice was removed with great rapidity. A tongue of ice flowed from Upper Teesdale by Yad Moss to the Valley of the South Tyne.

Similar evidence with regard to Weardale and the Tyne Valley is given, and the following conclusions are drawn among others:—Ice from Teesdale and the tributaries of the South Tyne occupied the valley of the latter nearly as far as Lambley, where it was joined by a large glacier which crossed the northern end of the Pennine Chain. This glacier was continuous in a northerly direction with the ice of the Southern Uplands and the glacier of the North Tyne, and, when at its maximum, deflected the last north-eastward, causing a movement in that direction along the southern flanks of the Cheviot Range. But at the beginning and end of the glaciation the ice in the Valley of the North Tyne flowed south-eastward. The southern margin of the South Tyne glacier passed across the heads of Allendale and Devil's Water into the Wear Valley; and along this margin were a series of ice-dammed lakes with a corresponding series of overflow-channels, many of which are now streamless. Weardale was mainly occupied by its own ice, but the lower part of the valley was invaded by the Tyne ice from the north and that of the Tees from the south. There were no lakes strictly connected with the last system.

CORRESPONDENCE.

DEAN BUCKLAND AND McENERY.

Sir,—May I call attention to a point in the history of geological science which seems in danger of falling into the realm of myth, and which apparently can yet have light thrown on it by at least two geologists, whose names are well known and honoured by all who desire that that history should be handed down to future generations in its integrity. I refer to Professor Rupert Jones and Mr. A. R. Hunt.

The first discoveries which led to the views now held as to the antiquity of man were made in Kent's Cavern in 1825–6 by the

Rev. John McEnery. Yet English science has lost the credit of priority by the fact that the records of these discoveries remained unpublished until 1859. It has been suggested that their publication was "suppressed," owing, according to one writer, to the influence of Huxley, of all men in the world. The erroneousness of this amazing statement was at once pointed out by the two geologists I have named. Mr. Hunt, however, associates the delay in the publication of the Kent's Cavern evidence with the delay in issuing that of the Brixham Cave. The two cases seem entirely distinct. McEnery's discoveries were made thirty years before the Brixham Cave was explored, and during that time many facts discovered on the Continent had come to light. Professor Rupert Jones, on the other hand, tells us that the notes, supposed to be "lost," were "really kept in the background by influence of the Rev. Dean Buckland." The Professor must be in possession of facts which are certainly not to be found in the evidence as it stands.

I have carefully studied the literature of the subject, and can find no suggestion of influence brought to bear by anyone with a view to suppression of publication of the notes. McEnery *may* have been deterred by fear of orthodox persecution, or out of deference to Dean Buckland, who differed from him in some of his conclusions, but there is no evidence for either theory. If I might suggest a reason for the non-appearance of the work during his lifetime, I should say it is to be found in the modesty, simplicity, and amiability of McEnery's character. His own story is perfectly explicit. His original intention was to publish the results of his researches at once. His private means being insufficient for this, he drew up a prospectus with the object of procuring pecuniary assistance, but apparently this prospectus was never issued. Partly on account of bad health, and partly in the belief that some one better equipped than himself in geology and palæontology would take the matter up, he abandoned the idea of publication, but continued adding to and altering his notes to such an extent that they became terribly confused. We find additions made to them as late as 1836, containing quotations from Buckland's Bridgewater Treatise, published in that year. Finally, shortly before his death, he again announced his intention of publishing his memoir forthwith. Unfortunately, he died in the beginning of 1841, without having even prepared his notes for the printer.

The subsequent history of his manuscript seems equally clear. His effects were sold by auction, and the precious notes happened to be mixed up in a miscellaneous 'lot' of sermons and other papers, which was purchased by Mr. Lear, a Torquay tradesman who collected fossils. From him, or perhaps after his death, they were purchased by Mr. W. Long, F.G.S., of Saxmundham. This gentleman had already shown much interest in cavern researches, and had communicated a paper on the subject to the British Association Meeting at Newcastle in 1838. He handed them over to Mr. Vivian with a view to their publication, which was effected in 1859. It is worthy of remark that for seven or eight years before that date, any influence on the part of Dean Buckland was out of the question. Professor Rupert Jones has, rightly, I think, referred to the statement regarding Huxley as "not only uncalled for, but unkind." Will he now, for the sake of historical accuracy, give us his reasons for placing the burden of responsibility on the shoulders of the Dean? And will Mr. Hunt let us have the "long story" so far as it refers to McEnery's notes? If, as he says, it dates "long subsequent to McEnery's death," again it is difficult to see where and how Dean Buckland's influence was exerted.

J. Adam Watson.

"Hay Tor," Dennington Park Road, Hampstead.
December 21st, 1901.

THE HOLOCENE DEPOSIT AT CASTLE CARY.

Sir,—In our recent paper on "The Post-Pliocene Non-Marine Mollusca of the South of England" (Proc. Geol. Assoc., vol. xvii, pt. 5), when speaking of the holocene deposit at Castle Cary (p. 234) we express regret that we were unable to obtain any information concerning it.

Our attention has now been called to the fact that an account of this alluvial deposit is given in the Geological Survey Memoir on East Somerset by Mr. H. B. Woodward, and we hasten to express our regrets to that author for the oversight. He gives the following list of shells which he obtained from the spot in 1868, viz.: "*Helix aspersa, H. nemoralis, Cyclas, Ancylus fluviatilis, Limneus, Unio* (fragments)." Of these, only one, the *Ancylus fluviatilis*, is common to our list; concerning the others, not having seen the specimens, we are unable to pronounce any opinion.

A. S. Kennard.
B. B. Woodward.

OBITUARY.

PROFESSOR RALPH TATE, F.L.S., F.G.S.

Born 1840. Died September 20, 1901.

If Professor Tate had remained in England his loss would have been severely felt by British geologists; as it is, that loss is to a large extent transferred to the Antipodes, where South Australia will increasingly lament the departure of one who has been so much to the science of the Colony. In this country his memory will linger chiefly in the minds of those who can look back beyond the last quarter of a century, but it will be a fond memory, based on sincere admiration of his powers and his character.

Ralph Tate was the nephew of the well-known geologist George Tate of Alnwick, where he was born in 1840. He received his primary education at the Cheltenham Training College, whence he was sent in 1857 to the Royal School of Mines, where he studied for two years. After some little practice in teaching at the Polytechnic he went to Belfast in 1861 as teacher of Natural Science at the Philosophical Institution, his principal subjects of interest being Botany, non-marine Conchology, and Geology, particularly the palæontological side of it. His first proceeding was to found the Belfast Naturalists Field Club, which is still in vigorous operation, and he also drew up a Flora of Belfast and, at a later date, a descriptive list of Irish Liassic Fossils, including several new species. An earlier paper on an allied subject contributed in 1864 to the Geological Society was followed by his removal to London as Assistant-Curator to the Society, the results of which appointment may be seen in the admirable condition as to naming, etc., of the specimens in the Society's Museum which came under his hand. Whilst in this position he contributed three papers to the Quarterly Journal—on the Cretaceous Rocks of the North-East of Ireland, on the Zone of *Ammonites angulatus*, and on the South African Fossils in the Museum—all highly palæontological. He was also at work in the other branches of Natural History which interested him, writing three Botanical papers in 1866 and a small textbook on Land and Fresh-water Mollusca. These various branches were so well handled that Lyell and Huxley amongst geologists, Gwyn Jeffreys amongst conchologists, and Hooker, Baker, and Carruthers amongst botanists nominated him as Associate of the Linnean Society in 1866.

In 1867 he was sent by the Central America Association on an exploring expedition to Nicaragua, and in the following year to Guyana in Venezuela, expeditions which resulted in papers to the Geological Society on the geology, and to the American Journal of Conchology on the non-marine Mollusca of those countries. In the interval and afterwards he conducted classes at the Mining School at Bristol, and also brought out his well-known Appendix to Woodward's Manual of Mollusca, and an admirable little class-book of geology forming two volumes of Weale's Rudimentary Series; at the same time he was communicating a series of Jurassic papers (four) to the Geological Society. In 1871 he was appointed teacher to the Mining School established by the Cleveland Ironmasters, first at Darlington and then at Redcar. His attention was thus drawn to Yorkshire, and ultimately led to his bringing out (in conjunction with the writer of this notice) his well-known work "The Yorkshire Lias."

About this time, however (1875), a complete change occurred in his life on his appointment as Professor of Natural Science on the Elder Foundation at the University of South Australia in Adelaide. To the work thus opened before him he henceforth devoted all his energies. He found there a Philosophical Society issuing no proceedings and studying science chiefly at second-hand. This Society he determined to raise to a high position by commencing a series of Transactions, and publishing in them his papers on the Geology and Natural History of the Colony, instead of sending them to better known and more widely circulating journals, and by persuading others to do the same. For three years he piloted this Society, first as Vice-President and constant Chairman (1877–8), and then as President (1878–80), by which time he had established it under the new title "The Royal Society of South Australia." In the twenty-four volumes issued up till now we find no less than ninety-one papers contributed by him: a few of these are botanical, others are on general geology, such as glaciation, but the greater number are on the Tertiary beds of the continent and their fossil Mollusca. On this subject he contributed also to the Proceedings of the Royal Society of Tasmania, of the Linnean Society of New South Wales, and of the Australian Association for the Advancement of Science, of which he was President in 1893. How broadly and firmly he thus laid the foundation of our knowledge of Molluscan phylogeny in the Australian province may be judged from a Catalogue of Tertiary Australian Mollusca in the British Museum issued in 1897. Out of 380 species therein recognized from the Australian continent, 225 are species established by him and 90 more are determined or recorded in his writings; every one of his species (with a single doubtful exception) is accepted by the author of that catalogue, and only four corrections of names are suggested. This is probably a 'record' result.

In 1888 Professor Tate took over the editorship of the Transactions, and with one short intermission continued it to the last. In 1893–5 he was again President as 'Governor's Representative,' and he took occasion to congratulate the Society on the position its Transactions had attained, and to thank the early contributors for their self-sacrifice for its sake in sending their papers to a publication then so obscure. Soon afterwards he learnt the price he had himself paid in doing the same. In the Autumn of 1896–7 he paid a visit to this country, and unhappily the opportunity was not seized of giving him that recognition of the value of his work which undoubtedly would have long ago been his had he remained in this country or sent his papers to European publications. He was somewhat disappointed at this, but let us hope he was a philosopher. At all events, he continued his work in his adopted country with undiminished zeal, and only the approach of his final malady put a period to his activity. Early this year heart trouble gradually became more serious, and brought his useful and honourable life to a conclusion on September 20th. He was twice married, and leaves behind him several children all well established in life, as is his own reputation in the minds of all palæontologists.

J. F. B.

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JAMES SHIPMAN, F.G.S.

BORN APRIL 30, 1848. DIED NOVEMBER 21, 1901.

AN energetic worker on geology has been lost to science in the death of Mr. James Shipman. In early life he was apprenticed to the printing trade; he subsequently entered the employment of the late Mr. Edmund Renals, then proprietor of the *Nottingham Daily Express*, and at the time of his death Mr. Shipman occupied a post on the sub-editorial staff. About the year 1868 he attended the science classes held by the late Edward Wilson, and in 1870 he won the bronze medal of the Science and Art Department for geology. Later on Mr. Shipman became a teacher in the science. He devoted himself with remarkable enthusiasm to the study of all the open geological sections in and around Nottingham, and furnished important aid to Mr. W. T. Aveline when he was revising the geological survey map of the district. He became an active member of the Nottingham Naturalists Society, contributing to its Transactions papers on the geology of various parts of Nottinghamshire and Derbyshire. The Drift deposits, the New Red Rocks, and the Coal-measures naturally attracted his chief attention, and so thoroughly sound was his knowledge that his advice was sought in various inquiries of economic importance. As a journalist his time was greatly occupied, and especially at night, so that it was only in leisure hours, often taken from those which should have been devoted to sleep, that he was enabled to give so much time to his favourite subject. In 1887 he published "Holiday Notes of a Geologist," a work which contained many interesting reminiscences. There can, however, be little doubt that by utilizing what he termed his 'free' days so fully, while labouring also at night, he too severely taxed his strength. He died suddenly at the age of 53.[1]

[1] We are indebted for most of the above particulars to an article by Mr. A. Stapleton in the *Nottingham Daily Express*.

MISCELLANEOUS.

British Museum (Natural History).—We have much satisfaction in announcing that Dr. Arthur Smith Woodward, F.R.S., F.L.S., F.G.S., has been appointed Keeper of the Geological Department of the British Museum in the room of Dr. Henry Woodward, who lately retired.

Royal Commission on Coal.—A Royal Commission on Coal has been appointed to inquire into the question of the Coal Supplies of the United Kingdom. The terms of reference are as follows :—

"To inquire into the extent and available resources of the coalfields of the United Kingdom ; the rate of exhaustion which may be anticipated, having regard to possible economies in use, by the substitution of other fuel or the adoption of other kinds of power ; the effect of our exports of coal on the home supply, and the time for which that supply, especially of the more valuable kinds of coal, will probably be available to British consumers, including the Royal Navy, at a cost which would not be detrimental to the general welfare ; the possibility of a reduction in that cost, by cheaper transport, or by the avoidance of unnecessary waste in working, through the adoption of better methods and improved appliances, or through a change in the customary term and provisions of mineral leases ; and whether the mining industry of this country, under existing conditions, is maintaining its competitive power with the coalfields of other countries."

The Commission is constituted as follows :—The Right Hon. W. L. Jackson, M.P., Chairman ; Sir G. J. Armytage, Bart. ; Sir W. T. Lewis, Bart., M. Inst. C. E. ; Sir Lindsay Wood, Bart., M. Inst. C. E. ; Thomas Bell, Esq. ; William Brace, Esq. ; A. C. Briggs, Esq. ; Professor H. B. Dixon ; J. S. Dixon, Esq. ; Professor C. Le Neve Foster, F.R.S. ; Dr. Edward Hull, F.R.S. ; Professor C. Lapworth, F.R.S. ; J. P. Maclay, Esq. ; Arthur Sopwith, Esq. ; J. J. H. Teall, Esq., F.R.S. ; and Ralph Young, Esq.

The previous Royal Commission appointed to inquire into the several matters relating to Coal in the United Kingdom held their first meeting in 1866 and reported in 1871. In our notice of their General Report,[1] we referred to the importance of settling the question whether or not there is coal at a workable depth in the southern and south-eastern portion of England, and we thought that the Government, while spending something like £30,000 in collecting evidence, much of it necessarily theoretical, might have spent a few thousand pounds in the practical work of boring. During the past thirty years public and private enterprise have done much to prove the depth to the Palæozoic floor in the east and south of England, but we have yet a good deal to learn on the subject. The discovery of Coal-measures at Dover has been most important, though the extent of the workable coal remains to be proved.

[1] Geol. Mag., 1871, Vol. VIII, p. 517.

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ORIGINAL ARTICLES.

I.—On the value of Mineral Condition in determining the Relative Age of Stone Implements.

By S. Hazzledine Warren, F.G.S.

The Classification of the Palæolithic Period.

THE common English classification of the Palæolithic Period into the epochs of the River-Drift Men and the Cave Men hardly conduces to clearness of thought. The implements of the River-Drift men are often found in the caves, and those of the Cave Men are very common in the river drifts. Although the caves and rock shelters bring us down to a later period than is usually represented in the river drifts (there appear to be exceptions to this[1]), yet the general succession in the two classes of deposits is the same, and they cannot be separated.

Without accepting all the more recently proposed earlier epochs,[2] I should certainly extend the classification one stage further backward in time than was originally done by M. de Mortillet.[3] That is to say, I would separate the derived implements from the contemporary Chelléo-Acheuléen implements of what are commonly called the 'high-level' river drifts. So far, I think, one may be fairly safe. For so far the relative ages of the implements are not inferred from their types, but the relative ages of the types, or rather of the series of types, are inferred from their mineral condition and the stratigraphical succession in which they are found. The peculiar types especially characteristic of one epoch are not confined to that epoch, but occur also in newer or in older epochs, or in both, as the case may be. But this fact does not prove the contemporaneity of our supposed epochs.

In all these problems one has to encounter a difficult combination of differences and resemblances. The implements of any one place

[1] See, for instance, Philippe Salmon, "L'Age de la Pierre à l'Exposition Universelle de 1889," Paris. Several later Palæolithic implements are figured on p. 29, etc., collected by M. G. d'Ault du Mesnil from the "Quaternaire moyen, assise supérieure" at Abbeville. Note also remarks towards the end of the present paper on Shrub Hill, Feltwell, etc.

[2] Some account of these may be found in various papers by M. A. Rutot in the Bull. Soc. belge Géol. Brux., 1900 and 1901, vols. xiv and xv.

[3] G. de Mortillet, "Classification des Diverses Périodes de l'Age de la Pierre": Congr. Inter. d'Anthrop. et d'Archéol. Préhist. Bruxelles, 1872, p. 432. "Le Préhistorique Antiquité de l'Homme," 1883, *passim.*

and time can be shown to have resemblances, more or less, with those of other places and other times. It is clear, however, that certain series of implements, found in certain beds, and possessing certain characters, are older or newer than other series of implements possessing different characters. But the fact that even the most highly specialized types are seldom absolutely confined to one epoch, shows that great caution must be exercised in drawing conclusions in the inverse order.

For convenience of reference I give the following modification of M. de Mortillet's scheme of classification, which, it seems to me, best expresses the relationships of the various epochs, and which I shall use in the course of this paper.

TABLE OF THE DIVISIONS OF THE PREHISTORIC AGE.

Periods.	Epochs with Type Stations or Examples.	Sequence Dates.
Recent (Holocene).	*Prehistoric Age of Metal.*	
	Prehistoric Iron Age. T.S.: La Tène (Palafitte), Lake Neuchatel	N. 90
	Presumed Transition Phase. T.S.: Hallstadt (cemetery), Austria	N. 80
	Later Bronze Age. Ex.: "La grande Cité" (Palafitte), Bay of Morges, Lake Geneva ...	N. 70
	Early Bronze Age, or Transition Epoch. Ex.: Palafitte of Roseaux, Bay of Morges, Lake Geneva	N. 60
	Neolithic Age.	
	Phase in which metal (copper and bronze) was known, but extremely scarce and little used. T.S.: Palafitte of Robenhausen	N. 50
	Presumed Earlier Phase, metal quite unknown. Ex.: the station of Campigny (Seine-Inférieure); also Cissbury (Sussex) and the Kjökkenmödding of Denmark (?)	N. 30
Pleistocene.	*Later Palæolithic Age.*	
	Magdalénien Epoch. T.S.: rock shelter of La Madelaine (Dordogne)	P. 90
	Solutréen Epoch. T.S.: "Le Clos du Charnier," at Solutré (Saône-et-Loire) ...	P. 80
	Middle Palæolithic Age.	
	Moustérien Epoch. T.S.: cave of Moustier (Dordogne)	P. 70
	Acheuléen Epoch. T.S.: the contemporary implements of the middle beds of the drift of Saint-Acheul (Somme)	P. 60
	Earlier Palæolithic Age.	
	?[Chelléen Epoch. T.S.: the earlier drift of Chelles (Seine-et-Marne).]	[P. 50]
	The earliest known phase of the Palæolithic Period. T.S.: the drifted Palæolithic (not 'Eolithic') implements of the Plateau Drift of Kent. (Appears to cover a long period and may be capable of subdivision.) ...	P. 30–40

In this table I have ventured to give 'sequence dates' to the epochs, after the system that has been used by Professor Flinders Petrie.[1] I have not attempted, however, to give a similar value to each unit of the scale, other than that suggested on taking a general view of the stratigraphical successions in various districts.

In doing practical work one finds at every turn the advantage of these 'sequence dates' over a system of epochs alone. Where the epoch of implements is but ill-defined, which is very often the case, these 'sequence dates' are of especial value. Instead of speaking of implements as Acheuléen, which may be far from contemporary with those properly belonging to that epoch, one can assign them as s.d. P. 50–70, or whatever it may be—just so much as can safely be made out.

I have queried the Chelléen Epoch, as a matter of doubt. What one might call the typical river-drift implements were originally called Acheuléen. Subsequently M. de Mortillet[2] thought that they showed evidence, at Saint-Acheul and elsewhere, of a transition to the Moustérien, and proposed that they should be called Chelléen, the Acheuléen being considered intermediate. Other workers, as M. G. d'Ault du Mesnil,[3] have considered the Chelléen and Acheuléen to be worthy of separation into two distinct periods. M. A. Rutot,[4] again, looks upon the Chelléen as a phase of transition between the earlier 'Mesvinien' and the Acheuléen. The point has not been satisfactorily cleared up, but there is evidently a gap between the Earlier Palæolithic (P. 30–40) and the Acheuléen (P. 60), and, in addition, there seems in some localities to be a series that is of intermediate age. But whether these apparently intermediate forms at P. 40–60 are really to be correlated with the Chelléen of Chelles I am not prepared to say. In using 'sequence dates' one need not debate the point. Until further exact work has cleared the matter up, it is more prudent to give them a sufficiently wide range to be safe in any event. In the table I have suggested P. 50 for the Chelléen, should that be found to be satisfactory, but for the present it is better to class both these and all other similar series at P. 40–60, and narrow the range down, at one end or the other, as evidence accumulates.

Local details, wherever these are obtainable, may be written thus: N. 40–60, l. 30–45, that is to say, there are a series of relics from some locality coming correlatively (but not necessarily contemporaneously) into the general scale at N. 40–60, of which the particular object or type classed comes into the local scale at 30–45. Or these formulæ may be written in the form of fractions or decimals, as may be most convenient for the work in hand.

There are many more points on which one might say much, but I think that what I have said is sufficient for my present purpose, so I will pass on to consider the question of the value of the mineral condition of stone implements as a test of their relative age.

[1] Journ. Anthrop. Inst., 1899, vol. xxix, pp. 295–301.
[2] "Le Préhist. Antiq.," etc., 1883, p. 133 et seq.
[3] Philippe Salmon: "L'Age de la Pierre," etc., 1889, p. 17.
[4] Bull. Soc. belge Géol. Brux., 1900, vol. xiv, p. 326.

The Mineral Condition of Stone Implements.

Every collector is familiar with the great variety in mineral condition presented by stone implements, according to the accidents of their preservation. Palæolithic implements are quite as often found unabraded, unaltered, or whitened in condition as they are abraded or with an ochreous patina. And, on the other hand, Neolithic implements are not only found unaltered or whitened, but occasionally also ochreous, especially where they were made of flint that previously had an ochreous patina. More than this: as an implement lay flat in a gravel bed, or whatever it might be, the upper surface is often in quite a different condition from the lower. Or, with an implement broken in early times, it is occasionally found that the two or more pieces, though fitting together accurately, are yet each in a different condition. It must be emphatically stated, then, that when implements are merely viewed in the trays of a cabinet, mineral condition is no test of age. It is equally notorious that rudeness of workmanship in individual specimens is no indication of antiquity. Very rude stone implements were made, not only during the Neolithic Period, but even, apparently, after the introduction of metal. From these causes the subject has fallen into discredit with many of our more cautious geologists. It has been too hastily assumed that the same is the case no matter what the circumstances may be under which they were found in the field.

With regard to rudeness of workmanship being no indication of antiquity, one might say more. The evolution of implements of certain types not only passes through successive phases of advancement, but also to this development there may succeed a degradation of form; probably, in most cases, through the introduction of some better material to supply the same needs. Professor Flinders Petrie[1] believes this to have been the case with the beautiful flint knives of Egypt. In the prehistoric graves he traces a certain succession (N. 40–55, l. 30–80), and finds that the curved knives with ripple flaking were developed at N. 40–55, l. 57, from a similar form made previously by irregular flaking. But these beautiful flat, ripple-flaked, knives only continued in use to N. 40–55, l. 65, after which time there was a recrudescence to the earlier style, and this continued in use into the early historic times.

One sees a similar phenomenon, on a larger scale, during the Palæolithic Period. The development of the flint-working industry may be traced[2] up through the Chelléo-Acheuléen and the Moustérien, until it reaches its highest excellence and skill in the Solutréen. But towards the end of that epoch the bone industry began to assume greater importance, until in the Magdalénien it attained an extraordinary development, while the flint industry fell comparatively into decay.

In September, 1900, I described in this Magazine a Palæolithic drift on High Down, in the Isle of Wight, and suggested that the

[1] Journ. Anthrop. Inst., 1899, vol. xxix, pl. xxxiii.
[2] G. de Mortillet: "Le Préhist. Antiq.," etc., 1883, pp. 355–367.

implements probably belonged to two distinct epochs. At about eighteen inches from the surface in this clay drift there was what I called a "layer of stones." On sorting out the flints (both worked and unworked) from this layer of stones, according to their mineral condition, I found that they fell into the following classes :—

A. Abraded and corroded ; with a deep brown patina.
B. Much corroded and abraded; whitened over an earlier ochreous staining. Not very abundant.
C. Somewhat abraded ; commonly mottled with white over a slight ochreous staining (red more often than brown or yellow) ; the whole patina very superficial.
D. Unabraded ; practically unaltered in condition.
E. Unabraded flint nodules and fragments ; more or less bleached white. Implements rare in this condition.

Leaving class C out of account for the moment, I will proceed to show that while A and B are derived from an earlier drift, D and E are contemporary, or nearly so, with the deposit in which they were embedded. One might hazard a guess that A and B were older than D and E, simply from the fact of their being abraded, corroded, and ochreous in condition, but a more careful examination shows the evidence to be far stronger than this alone would be.

Many of the flints in condition A and B are found to be broken across, the later fractures being in condition D or E. These specimens, showing fractures of two different ages, are clearly defined from those which show a different condition on their two surfaces through some accident of preservation. Firstly, the later fractures in the former case very rarely occupy exactly one surface of the flint. Sometimes the newer fractures are a mere chip on the edge, sometimes it is a corner of the flint that has been knocked off, or sometimes the flint has been broken up and only a very small surface in the earlier condition remains. Secondly, these later fractures show all round their edges a clear section of the earlier deep patina of the flint : this is the absolute distinction between them.

Under these conditions, whatever value the difference in age may have, it is demonstrable that the deeper patina is geologically older than the later fracture which crosses it, though this later fracture may also be of geological antiquity. Mr. Worthington G. Smith[1] has figured and described ochreous abraded implements showing later fractures on their edges, and strongly insisted on this proof of their greater antiquity.

It is, after all, only applying the well-known, and fully admitted, principle in stratigraphy, of discriminating between contemporary and *remanié* fossils, to the similar problems presented by flint implements. But, undoubtedly, caution and judgment must be exercised in applying the principle. Differences of condition, of the kind that have been pointed out, prove differences of age, but they do not immediately prove that every difference in age belongs to

[1] "Man the Primeval Savage," 1894, p. 216.

a distinct epoch or stage of human culture. Nor does the condition of the flints, by itself, show to which phase they should be referred.

In the "Grotte du Placard" (Charente)[1] there are eight relic beds, each separated by an accumulation of rock débris, and yet these can only be referred to four of the epochs. The lowest bed is Moustérien (P. 65–75), the next two Solutréen (P. 75–85, l. 30; and, say, l. 50 or 60), the succeeding four Magdalénien (P. 85–95, l. 30, l. 40, l. 50, and l. 60), and the uppermost Neolithic.[2]

Turning again to the High Down Drift of the Isle of Wight: in my earlier work here I was rather puzzled with the implements from the "layer of stones" already mentioned. Some of them, those of classes A and B, were clearly derived. Others, those of class D, were as clearly contemporary; and, as I afterwards found, some of the flakes were lying close to the cores from which they had been struck off, several of which I have been able to replace. But a certain number of the implements, those of class C, were not quite in accordance with either of the foregoing classes. These were somewhat ochreous for the most part; they seemed to be derived, and yet they were not much abraded, and not in the least corroded or deeply altered as those of classes A and B. They seemed to be intermediate between the two extreme forms, and yet, having in mind at that time rather an idea of 'epochs' than the idea of 'sequence dates,' I hesitated to refer them to an intermediate age. But that they are of intermediate age I have now no doubt, and last Summer I found a broken pointed implement that went far to confirm my opinion. A portion of the butt of this specimen shows a natural fracture in the earliest, corroded, condition. This is cut across by the working of the implement. The worked surface, though it shows a section of the earlier patina, is itself a little abraded and slightly altered; the point of the implement being broken off by what, if I am not mistaken, is a still later fracture, contemporary with the unaltered implements. Thus, in addition to the numerous implements, and still more numerous unworked flints, which show two out of the three main conditions, I at last found all these conditions, marked off from each other, upon the same implement.

If my conclusions are sound, then, and the implements of class C are derived, those of classes A and B must be twice derived. It would be exceedingly difficult to show from the specimens themselves that the brown corroded flints of class A had been twice derived, but an examination of those of class B brings to light certain facts that point in that direction. Among these (class B) there is a rude outer flake with large *éraillure*. The surface of this is much corroded and abraded, and shows the white patina caused by weathering. Beneath this whitening there is seen, on the

[1] A. de Maret: "Fouilles de la grotte du Placard, près de Rochbertier"; Tours, 1879. G. de Mortillet: "Musée Préhistorique," 1881, pl. xxix.

[2] Professor Flinders Petrie begins his local scale at 30, in order to allow for future discoveries, and it is as well to carry out that system uniformly, wherever it may be possible to do so.

broken edges, an earlier ochreous staining. All round the edges there are abrasions which are later than the whitening, these later abrasions being in condition B. Thus we see that this flake lay for a long period on the surface, exposed to the influences of the atmosphere, between the time of an earlier ochreous staining (almost certainly preceded by abrasion) and a later abrasion. It seems most probable that when these flints of class B were washed out of their early drift and exposed on the surface, those of class A were also washed out of that first drift and embedded in a second, to be again re-drifted and buried together in the present drift, mingled with contemporary implements. The later abrasions of class B are very possibly contemporary with the implements of class C, but I do not like to force the evidence too far. What has been said is enough to show what a long history of successive abrasions these early implements have suffered; and further, by careful attention to their condition, that it is possible, in some measure at least, to read what that history has been.

I should hesitate, from the material at my disposal, to class either of these three ages as of either Acheuléen or Moustérien or of any other epoch. But by an examination of their style of workmanship and their types, one can easily fix their position, within certain broad limits, in the 'sequence date' scale. The rude ovate and other implements of the oldest series fall into the scale at P. 30–45; the next series at P. 45–65; while the latest implements consist of the waste product of a workshop, spalls, cores, and 'wasters' or *ébauches*, from which little can safely be inferred. They seem to come in at P. 65–80, but as they are ill-defined it is better to class them as P. 60–99.

It may be worth while to mention, in passing, that calcined flints are not uncommon in this layer of stones. There can be no doubt that these were burnt by the fires lighted by the Palæolithic men who made the latest of these implements.

In another layer of stones,[1] above the one I have been dealing with, there are other implements. The number I have is not very large, but they include: ochreous, abraded, derived forms, apparently about P. 30–50; ochreous, almost unabraded implements of skilful workmanship, evidently drifted, but from no great distance, apparently P. 60–70; together with a few flakes and cores, contemporary (quite unabraded) and whitened in condition, which may very probably be Palæolithic, but about whose exact position in the drift I am uncertain. At present, at least, they are of no particular interest.

It sometimes happens that an implement not only shows later accidental fractures which are contemporary with another series of implements, but even a later working. These re-worked examples have been recorded by many observers, and I have a good example from Santon Downham, Suffolk, near Thetford, to which locality I shall refer again towards the end of this paper.

Flints may become chipped, through movements of the soil,

[1] Geol. Mag., September, 1900, p. 407.

while they lie in place in their beds, and these chips will then be no evidence of derivation. This possibility of error must be carefully guarded against. Chipping produced in this way has, in general, certain characters by which it may be distinguished, as I hope to show very shortly. And, in addition, if these chips were made in the bed in which the flint lay up to the time it was discovered, they will not be abraded and water-worn as they are when the flint is truly derived.

To satisfy the requirements of clear proof, these contemporary and derived implements must have been buried together in a bed of proved age. With regard to Palæolithic implements found on the surface of the ground, little can be inferred as to their relative age; except, more or less doubtfully according to circumstances, by a comparison of their types with those where stratigraphical evidence is obtainable. The evidence of later fractures on patinated flints is obviously inapplicable to implements found on the surface, for the age of these later fractures cannot be ascertained, except, perhaps, in cases of re-working. But where a variety of implements are found together on the surface, and the deeply patinated forms are uniformly of Palæolithic type, while those not so patinated are of Neolithic type, I think one may be perfectly safe in referring the former to some part of the Palæolithic Period.

Sir Henry Howorth,[1] in a recent number of this Magazine, has referred to Dr. H. O. Forbes'[2] unfavourable conclusions as to the presumed Palæolithic age of certain Egyptian implements. But one cannot feel assured that the *ébauches* or 'wasters' of the comparatively recent flint workshops, even though some of them are of Palæolithic form and much patinated, are really the same as the presumed Palæolithic implements spread over the surface of the desert. Such old forms occur also in company with Neolithic remains in England. One can only judge the age of surface implements by the facies of a considerable number that appear to be in undoubted association with each other. And so far as one may judge from the accounts of those who have collected in the district, the general facies of the implements in dispute is pretty clearly Palæolithic.

The Evidence of Mineral Condition applied to the River Drifts.

Almost everywhere where Palæolithic implements have been collected with sufficient care, stratigraphical evidence, in one form or another, is forthcoming to indicate differences in age and a certain definite succession.

If we turn to the so-called high-level gravels of our river valleys, we find, for instance, at Stoke Newington:[3] a derived series, often, but not always, with an ochreous patina (P. 30–40); a series abraded to some extent, but not derived (P. 55–60); and an

[1] Geol. Mag., August, 1901, pp. 337–344.
[2] Bull. Liverpool Museums, 1900, vol. ii, pp. 77–115; 1901, vol. iii, pp. 48–61.
[3] Worthington G. Smith: "Man the Primeval Savage," 1894, p. 189 et seq.

unabraded contemporary series (P. 65–75), confined to a definite horizon (the 'Palæolithic Floor'), above that of the earlier implements. Thus we see that at the time P. 65–75 the implements of P. 30–40 held very much the same position in those river gravels which Palæolithic implements generally hold in our modern river gravels; while the intermediate series (P. 55–60) were being rolled about in the bed of the river, then swifter and broader than at present, just as Neolithic implements are lying in the beds of our rivers to-day.

At the 'high-level terrace' of Saint-Acheul, near Amiens, again, we find: a derived series (P. 30–50, probably P. 30–40); perhaps an early contemporary series at the base of the deposit (? P. 40–55); an unabraded and contemporary series in the middle beds (P. 60); while another contemporary unabraded series occurs in the brickearth above (P. 65–75). There are also others (P. 60–80) in the lower drifts of Menchecourt, etc., and, as already mentioned, perhaps still later forms (? P. 75–90) in the later brickearths.

I will refer to only one other district—one where the phenomena are widely different from either Stoke Newington or Saint-Acheul—and that is the country around Thetford and Mildenhall.[1] Here there is, first, the high-level terrace of Brandon Down and Lakenheath, which is unconnected with the present river system. These gravels yield implements (P. 30–50) which often seem to have been derived from the surface soil of the period rather than from an earlier drift, together with contemporary forms (P. 50–65). Below these high-level gravels there are, in the present valleys of the Little Ouse and the Lark, the deposits of High Lodge, near Mildenhall, and Santon Downham, near Thetford, yielding contemporary implements (P. 65–75); while at various levels below these, in the same valleys, there are the gravels of Warren Hill, near Mildenhall, Redhill, near Thetford, Shrub Hill, in the parish of Feltwell, and other places, containing a mixture of derived implements of various ages (P. 30–75), together with a certain proportion of contemporary implements (P. 75–99), especially at Shrub Hill. Some of these last implements are of the usual Palæolithic types, some remind one of the ruder forms of the Neolithic Period, while others are almost counterparts of the surface implements, of somewhat uncertain age, from the Plateau of Leugny (Vienne) and other places in Poitou and Brittany.

Conclusion.

Although it is perfectly true that no conclusions can be drawn either from mere rudeness of workmanship in individual specimens, or from a few implements chancing to have, or not to have, an ochreous patina, yet I am confident that it is from such evidence as is indicated in this paper, that the more detailed history of early man must be read.

[1] The best general account of this district is to be found in Sir John Evans' "Ancient Stone Implements," 1897, 2nd ed., pp. 543–572.

II.—On an *Alveolina*-Limestone and Nummulitic Limestones from Egypt.

By Frederick Chapman, A.L.S., F.R.M.S.

Part II.

(Plates IV and V.)

FORAMINIFERA.

MILIOLINA, Williamson [1858].

Miliolina inflata (d'Orbigny).

Triloculina inflata, d'Orbigny, 1846: Foram. Foss. Vienne, p. 278, pl. xvii, figs. 13–15.

This species is fairly common in the *Alveolina*-limestone of the present series, occurring both in the powdered rock and in thin sections. For the previous occurrences of the species in Egypt see Geol. Mag., 1900, p. 7.

Nos. 3,335*b* and *c*. Farafra Oasis: Libyan Series.

Miliolina trigonula (Lam.).

M. trigonula (Lam.), Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 86, pl. xxiv (i), figs. 6*a–d*. Chapman, 1900: Geol. Mag., p. 6.

A single specimen, rather quinqueloculine than trigonuline in contour, was isolated from the *Alveolina*-limestone.

No. 3,335*b*. Farafra Oasis: Libyan Series.

ALVEOLINA, d'Orbigny [1826].

Alveolina ellipsoidalis, Schwager.

Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 96, pl. xxv (ii), figs. 1*a–i*, 2*a–c*. Chapman, 1900: Geol. Mag., p. 8.

This species was described by Schwager from Dr. Schweinfurth's specimens which the latter obtained from Wadi Natfe. It has also been found by the writer in *Patellina*-limestone from a locality between Cairo and Suez. This present occurrence seems to support the idea which Blanckenhorn has already advanced,[1] that the rock which yielded *Patellina* is of earlier date than Miocene, to which it was thought referable, though with some reservation. In the present series *A. ellipsoidalis* is somewhat rare.

Farafra Oasis. Nos. 3,335*b* and *c*. Libyan Series.

Alveolina decipiens, Schwager.

Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 103, pl. xxvi (iii), figs. 1*a–k*.

This form is easily recognized among the separated specimens by its large size. In shape it is ellipsoidal, but with blunt ends. Internally it is distinguished from *A. pasticillata* by the shape of the septal canals.

Frequent. Specimens 3,335*b* and *c*. Farafra Oasis: Libyan Series.

[1] Zeitschr. deutsch. geol. Gesellsch., 1900, p. 431.

Alveolina decipiens, var. dolioliformis, Schwager.

Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 103, pl. xxv (ii), figs. 7*a–g*.

A few isolated specimens of this variety were noted among the other *Alveolinæ*. It has the test sunken in the umbilical centres.

Specimens 3,335*b* and *c*. Farafra Oasis: Libyan Series.

Alveolina pasticillata, Schwager.

Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 104, pl. xxvi (iii), figs. 2*a–h*.

This rotund species is by far the commonest in our collection of *Alveolinæ*. It was previously recorded from Wadi Natfe, Nekeb-el-Farudj, and El-Guss-Abu-Said, by Schwager.

Very abundant. Specimens 3,335*b* and *c*. Farafra Oasis: Libyan Series.

PLACOPSILINA, d'Orbigny [1850].

Placopsilina cenomana, d'Orbigny. (Pl. V, Fig. 4.)

D'Orbigny, 1850: Prodrome Paléont., vol. ii, p. 185, No. 758. Brady, 1884: Rep. Chall., vol. ix, p. 315, pl. xxxvi, figs. 1–3.

The occurrence of the present specimen is of considerable interest, since the species has never been recorded from Tertiary beds, although it is a well-known form in deposits of Cretaceous age as well as those of recent date.

One small but perfect specimen, attached to a shell-fragment. Specimen 3,335*b*. Farafra Oasis: Libyan Series.

TEXTULARIA, Defrance [1824].

Textularia, sp. near gramen, d'Orbigny.

T. gramen, d'Orb., 1846: Foram. Foss. Vienne, p. 248, pl. xv, figs. 46.

This genus is here represented by a single specimen, seen in section, from the limestone of the Baharia Oasis. Its outline is like that of *T. gramen*, but we cannot be quite certain of the species, since no other sections were seen, nor specimens isolated from the rock. None of the examples of *Plecanium* figured by Schwager quite match our specimen.

No. 1,480*e*. Plateau west of Baharia Oasis: Lower Mokattam Series.

VALVULINA, d'Orbigny [1826].

Valvulina Schwageri, sp. nov. (Pl. V, Figs. 5*a–d*.)

Clavulina sp., Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, pl. xxvi (iii), figs. 19*a*, *b*.

Test triserial, triangular in outline, consisting of about five series of chambers arranged as in *Verneuilina*. The angles of the test slightly rounded, the faces slightly concave. Aperture valvuline, seen more distinctly in section than in the isolated specimens. Length, 1·1 mm.; greatest breadth, ·8 mm.

This form has already been figured by Schwager and referred to as *Clavulina* sp., but no specific name was assigned to it.

The sections of this species are numerous in the thin slices of the Farafra limestone. It was from this particular rock that Schwager obtained his examples.

Specimens 3,335*b* and *c*. Farafra Oasis: Libyan Series.

BULIMINA, d'Orbigny [1826].

BULIMINA ELEGANTISSIMA, d'Orb., var. SEMINUDA, Terquem. (Pl. V, Figs. 5*a*, *b*.)

Bulimina seminuda, Terquem, 1882: Mém. Soc. géol. France, ser. III, vol. ii, Mém. iii, p. 117, pl. xii, fig. 21.

B. elegantissima, d'Orb., var. *seminuda*, Terquem, Brady, 1884: Rep. Chall., vol. ix, p. 403, pl. L, figs. 23, 24.

Terquem's specimens came from the Eocene of the Paris Basin. The recent examples are most typical from shallow water.

This species is represented in the series now described by a single example, slightly more crispate in form, but otherwise typical. This is its first occurrence in the Egyptian Eocene.

No. 3,335*b*. Farafra Oasis: Libyan Series.

GLOBIGERINA BULLOIDES, d'Orbigny.

D'Orbigny, 1826: Ann. Sci. Nat., vol. vii, p. 277, No. 1; Modèles, Nos. 17 and 76. Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 118, pl. xxvii (iv), figs. 5*a–c*.

The whole of the present material has yielded only one specimen of the above form; Schwager's examples also came from the Mokattam Series.

No. 1,480*e*. Plateau west of Baharia Oasis: Lower Mokattam Series.

GLOBIGERINA CRETACEA, d'Orbigny.

D'Orbigny, 1840: Mém. Soc. géol. France, vol. iv, p. 34, pl. iii, figs. 12–14.

This species is not uncommon in sections of the Lower Libyan limestone; it is possibly derived from Cretaceous beds.

No. 1,531*f*. North of Mendische, Baharia Oasis: Libyan Series.

DISCORBINA, Parker & Jones [1862].

DISCORBINA PARISIENSIS (d'Orbigny).

Rosalina parisiensis, d'Orbigny, 1826: Ann. Sci. Nat., vol. vii, p. 271, No. 1; Modèles, No. 38.

Pulvinulina cf. *campanella*, Gümbel, Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 131, pl. xxviii (v), figs. 3*a–d*.

Schwager's figure appears to be that of a discorbine form, and one of our specimens exactly matches it. There is little doubt as to its relationship with the *Rosalina parisiensis* of d'Orbigny.

Nos. 3,335*b* and *c*. Farafra Oasis: Libyan Series.

TRUNCATULINA, d'Orbigny [1826].

TRUNCATULINA CANDIDULA (Schwager).

Pulvinulina candidula, Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 133, pl. xxviii (v), figs. 10*a–d*.

A specimen of the above occurs in our Upper Libyan (*Alveolina*) limestone. Schwager's specimens, however, came from the

Mokattam Series of Aradj and Turra near Cairo. The fact that the shell-texture is distinctly porous, as is also stated by Schwager, shows that the species properly belongs to *Truncatulina* and not to *Pulvinulina*.

Nos. 3,335*b* and *c*. Farafra Oasis : Libyan Series.

TRUNCATULINA UNGERIANA (d'Orbigny).

Rotalia Ungeriana, d'Orbigny, 1846 : Foram. Foss. Vienne, p. 157, pl. viii, figs. 16–18.
Pulvinulina mokattamensis, Schwager, 1883 : Palæontographica, vol. xxx, Pal. Theil, p. 134, pl. xxviii, figs. 11*a–d*.

This widely distributed species is quite common in the *Alveolina*-limestone of Farafra. It is a well-known form in all Tertiary deposits.

Nos. 3,335*b* and *c*. Farafra Oasis : Libyan Series.

AMPHISTEGINA, d'Orbigny [1826].

AMPHISTEGINA LESSONII, d'Orbigny.

A. Lessonii, d'Orb., 1826 : Ann. Sci. Nat., vol. vii, p. 304, No. 3, pl. xvii, figs. 1–4 ; Modèles, No. 98.

The sample of limestone from Wadi Dara, east of the Red Sea Hills, contains many specimens of *A. Lessonii* associated with large *Heterosteginæ*. The former are somewhat flat varieties of the species, and but for their inequilateral shape when cut through the umbonal axis, might almost be mistaken for small nummulites as *N. variolaria*.

No. 2,195, 1*h*. Wadi Dara, east of Red Sea Hills : Miocene.

OPERCULINA, d'Orbigny [1826].

OPERCULINA COMPLANATA (Defrance), var. CANALIFERA, d'Archiac.

O. libyca, Schwager, 1883 : Palæontographica, vol. xxx, Pal. Theil, p. 142, pl. xxix (vi), figs. 2*a–g*.
O. complanata (Defr.), var. *canalifera*, d'Archiac, Chapman, 1900 : GEOL. MAG., p. 7, Pl. XIII, Figs. 3*a*, 4*a* ; Pl. XIV, Fig. 12.

This variety is met with in two of the samples, which are both from the Baharia Oasis. The length of the largest specimen is 9·5 mm.

No. 1,531*f*. North of Mendische, Baharia Oasis : very abundant ; Lower Eocene : Libyan Series. Also No. 3,348*g*, N.N.W. of Bawitti, Baharia Oasis ; a few scattered and broken specimens. Lower Eocene : Libyan Series.

OPERCULINA COMPLANATA (Defrance), var. DISCOIDEA, Schwager.

O. discoidea, Schwager, 1883 : Palæontographica, vol. xxx, Pal. Theil, p. 145, pl. xxix (vi), figs. 5*a–d*.
O. complanata (Defr.), var. *discoidea*, Schwager, Chapman, 1900 : GEOL. MAG., p. 8, Pl. XIV, Fig. 13.

In cross-section this variety is easily distinguished from the preceding form by the very pronounced septal ridges which stand out prominently from the lateral shell-surface.

West of Bawitti, on plateau west of Baharia Oasis, No. 1,480*e*. Common. Middle Eocene : Lower Mokattam Series.

OPERCULINA COMPLANATA (Defr.), var. PYRAMIDUM, Ehrenberg, var.

Planulina pyramidum, Ehrenberg, 1838: Abhandl. k. Wiss. Berlin, p. 93, pl. iv, fig. 7.
Operculina pyramidum (Ehr.), Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 143, pl. xxix (vi).

From a zoological standpoint this variety is fairly comparable with *granulosa* of Leymerie, but since it shows some little differences from the strongly beaded form just named, in having a somewhat neater test, we may perhaps retain for the Egyptian specimens the name which Ehrenberg gave. It is easily separated from the two preceding in thin sections of the rock, by its having a thicker test, and the secondary bead ornamentation along the septal ridges.

No. 3,535, 52*l*. North of Salamuni, between Assiut and Qena, east side of Nile. Common. Lower Eocene: Upper Libyan Series.

HETEROSTEGINA, d'Orbigny [1826].

HETEROSTEGINA DEPRESSA, d'Orbigny.

H. depressa, d'Orbigny, 1826: Ann. Sci. Nat., vol. vii, p. 305, No. 2, pl. xvii, figs. 5–7; Modèles, No. 99. Chapman, 1900: GEOL. MAG., p. 8, Pl. XIII, Fig. 7*a*.

This is an extremely abundant form in one of the limestones, where it is represented by some thin, large, flexuose tests (2,195, 1*h*), frequently measuring 7 mm. in diameter. The second occurrence is in the *Alveolina*-limestone (3,335*b* and *c*), and there we have met with only one example, probably a young individual, closely resembling d'Orbigny's *Heterostegina simplex* of the Vienna Tertiaries.

Specimen 2,195, 1*h*. Two kilometres north-west of Camp 49, Wadi Dara, east of Red Sea Hills. Miocene.

Specimens 3,335*b* and *c*. Western wall of depression, Farafra Oasis. Lower Eocene: Libyan Series.

NUMMULITES, Lamarck [1801].

NUMMULITES BIARRITZENSIS, d'Archiac, var. PRÆCURSOR, De la Harpe.

De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 170, pl. xxx (i), figs. 21–28.

The variety is more compressed than the type, and has generally a sharper edge. The central chamber is almost invisible. De la Harpe described this variety from the grey marl of the lower Libyan Series east and west of Farafra.

Nos. 3,335*b* and *c*. *Alveolina*-limestone, from western wall of depression, Farafra Oasis. Rather rare. Lower Eocene: Libyan Series.

Also doubtfully from specimen 3,348*g*. Eight kilometres N.N.W. of Bawitti, Baharia Oasis. Lower Eocene: Libyan Series.

NUMMULITES GUETTARDI, d'Archiac & Haime, var. ANTIQUA, De la Harpe.

De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 172, pl. xxx (i), figs. 37–42. Chapman, 1900: GEOL. MAG., p. 10, Pl. XIII, Fig. 6*b*.

The only occurrence for this variety in the present series is in the much altered and recrystallized limestone from the Baharia Oasis.

Specimen 3,348*g*. Eight kilometres N.N.W. of Bawitti, Baharia Oasis. Frequent. Lower Eocene: Libyan Series.

NUMMULITES RAMONDI, Defrance.

N. Ramondi, Defrance, 1825: Dict. Sci. Nat., vol. xxxv, p. 224. Chapman, 1900: GEOL. MAG., p. 10, Pl. XIII, Figs. 3*b*, 4*b*.

Specimen No. 1,531*f*. Eight kilometres north of Mendische, Baharia Oasis. Common. Lower Eocene: Libyan Series.

NUMMULITES VARIOLARIA (Lamarck).

N. variolaria (Lam.), De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 179, pl. xxxi (ii), figs. 28–36. Chapman, 1900: GEOL. MAG., p. 11, Pl. XIII, Fig. 2*b*.

This species is one of the commonest in the present series of limestones in the two samples quoted below. Some of the specimens are very small, measuring as little as 1 mm. in diameter. They are well characterized by the large central chamber, and usually have from three to four turns to the shell.

Specimen 2,195, 1*h*. Two kilometres north-west of Camp 49, Wadi Dara, east of Red Sea Hills. Common. Miocene.

Specimen 1,531*f*. Eight kilometres north of Mendische, Baharia Oasis. Very common. Lower Eocene: Libyan Series.

NUMMULITES BEAUMONTI, d'Archiac.

De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 180, pl. xxxi, figs. 37–47.

Our largest specimens exceed the measurement given by De la Harpe by ·5 mm., and a fair number attain his maximum diameter of 12 mm. The distinctive characters of this form are, when seen externally, the medium thick test, evenly lenticular or slightly flexuose in edge view, and the shell surface marked with fine radial lines. The test is from 4 to 12 mm. or more in diameter, and from 2 to 4 mm. thick; the whorls number, according to De la Harpe, twelve to thirteen on a radius of 4 mm. and sixteen on a radius of 7 mm.

It has been recorded from the Mokattam, Wadi-el-Tih, near Heluan, on the Jebel Achmar, on the pyramids of Gizeh; also between the Nile Valley and the Farafra, Baharia, and Siuah Oases.

Specimen 3,535, 52*l*. North of Salamuni, between Assiut and Qena, east side of Nile. Common. Lower Eocene: Upper Libyan Series.

Specimen 1,516*h*. 17 kilometres N.N.E. of Ain-el-Haiss, Baharia Oasis. Abundant. Middle Eocene: Lower Mokattam Series.

NUMMULITES SUB-BEAUMONTI, De la Harpe.

N. sub-Beaumonti, De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 182, pl. xxxi (ii), figs. 48–56.

This form is associated with the preceding, and occurs in the two samples before quoted, namely, specimens 3,535, 52*l*, and 1,516*h*. It is smaller than *N. Beaumonti*, measuring $1\frac{1}{2}$ to 5 mm., and it is stouter in comparison, being from 1 to $2\frac{1}{2}$ mm. thick.

NUMMULITES DISCORBINA, Schlotheim.

Lenticulites discorbina, Schlotheim, 1820: Petrefactenkunde, p. 89.
Nummulites discorbina (Schlotheim), De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 183, pl. xxxii (iii), figs. 1–7.

A small nummulite with a thick, rounded test, and numerous whorls (maximum fourteen on a radius of 4 mm.). Usually associated with *N. Beaumonti* and allied forms, although our samples prove an exception.

Specimen 1,480*e*. West of Bawitti, on plateau west of Baharia Oasis. Common. Middle Eocene: Lower Mokattam Series.

NUMMULITES SUBDISCORBINA, De la Harpe.

N. subdiscorbina, De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 185, pl. xxxii (iii), figs. 8–15. Chapman, 1900: GEOL. MAG., p. 11, Pl. XIII, Fig. 1.

Specimen 1,480*e*. West of Bawitti, on plateau west of Baharia Oasis. Frequent. Middle Eocene: Lower Mokattam Series.

NUMMULITES GIZEHENSIS (Forskål), Ehrenberg, var. PACHOI, De la Harpe.

N. Gizehensis var. *Pachoi*, De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 193, pl. xxxiii (iv), figs. 14–18; pl. xxxiv (v), figs. 1–5. Chapman, 1900: GEOL. MAG., p. 12.

This variety has already been recorded from the Baharia Oasis by De la Harpe. It occurs in the present series in two samples from the same locality, namely, specimens 1,467*d* and 1,480*e*, 39 kilometres west of Bawitti, on plateau west of Baharia Oasis. Common. Middle Eocene: Lower Mokattam Series.

NUMMULITES CURVISPIRA, Savi & Meneghini.

Nummulina curvispira, Savi & Meneghini, 1851: Consid. Geol. Toscana, p. 137.
N. curvispira (Menegh.), De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 200, pl. xxxiv (v), figs. 42–67. Chapman, 1900: GEOL. MAG., p. 13, Pl. XIII, Fig. 5.

Typical specimens of the above were found in four of the samples of the present collection. In that from Jebel Hamrawen this species forms a large proportion of the rock, and is near the normal size, measuring 1·5 mm. in diameter.

Specimens 1,622, 56*h*, and 1,622, 6*k*, under Eocene nodular bed near Jebel Hamrawen. Very abundant.

Specimen 1,467*d*. 39 kilometres west of Bawitti, on plateau west of Baharia Oasis. Common.

Specimen 1,480*e*. Same locality. Occasional. Middle Eocene: Lower Mokattam Series.

ORBITOIDES, d'Orbigny [1847].

ORBITOIDES (DISCOCYCLINA) DISPANSA (Sowerby).

Lycophris dispansus, Sowerby, 1837 [1840]: Trans. Geol. Soc. Lond., ser. II, vol. v, pp. 327, 718, pl. xxiv, figs. 16, 16*a*, *b*.

It appears that this species has not been recorded before from the Baharia Oasis.

Specimen 1,480*e*. West of Bawitti, on plateau west of Baharia Oasis. Very rare. Middle Eocene: Lower Mokattam Series.

SECTIONS OF EOCENE FORAMINIFERAL LIMESTONES FROM EGYPT.

SPECIES MENTIONED IN THIS PAPER.

1. *Bairdia subdeltoidea* (Münster). Eocene: Farafra Oasis.
2. *B. Beadnelli*, sp. nov. Eocene: Farafra Oasis.
3. *B. minuta*, sp. nov. Eocene: Farafra Oasis.
4. *Cythere Farafrensis*, sp. nov. Eocene: Farafra Oasis.
5. *Miliolina inflata* (d'Orb.). Eocene: Farafra Oasis.
6. *M. trigonula* (Lam.). Eocene: Farafra Oasis.
7. *Alveolina ellipsoidalis*, Schwager. Eocene: Farafra Oasis.
8. *A. decipiens*, Schwager. Eocene: Farafra Oasis.
9. *A. decipiens*, var. *dolioliformis*, Schwager. Eocene: Farafra Oasis.
10. *A. pasticillata*, Schwager. Eocene: Farafra Oasis.
11. *Placopsilina cenomana*, d'Orb. Eocene: Farafra Oasis.
12. *Textularia*, sp. near *gramen*, d'Orb. Eocene: Baharia Oasis.
13. *Valvulina Schwageri*, sp. nov. Eocene: Farafra Oasis.
14. *Bulimina elegantissima*, d'Orb., var. *seminuda*, Terquem. Eocene: Farafra Oasis.
15. *Globigerina bulloides*, d'Orb. Eocene: Baharia Oasis.
16. *G. cretacea*, d'Orb. Eocene: Baharia Oasis.
17. *Discorbina parisiensis* (d'Orb.). Eocene: Farafra Oasis.
18. *Truncatulina candidula* (Schwager). Eocene: Farafra Oasis.
19. *T. Ungeriana* (d'Orb.). Eocene: Farafra Oasis.
20. *Amphistegina Lessonii*, d'Orb. Miocene: east side of Red Sea Hills.
21. *Operculina complanata* (Defr.), var. *canalifera*, d'Archiac. Eocene: Baharia Oasis.
22. *O. complanata* (Defr.), var. *discoidea*, Schwager. Eocene: Baharia Oasis.
23. *O. complanata* (Defr.), var. *pyramidum* (Ehr.). Eocene: between Assiut and Qena, east side of Nile.
24. *Heterostegina depressa*, d'Orb. Eocene: Farafra Oasis. Miocene: east of Red Sea Hills.
25. *Nummulites Biarritzensis*, d'Archiac, var. *præcursor*, De la Harpe. Eocene: Baharia and Farafra Oases.
26. *N. Guettardi*, d'Archiac & Haime, var. *antiqua*, De la Harpe. Eocene: Baharia Oasis.
27. *N. Ramondi*, Defr. Eocene: Baharia Oasis.
28. *N. variolaria* (Lam.). Eocene: Baharia Oasis.
29. *N. Beaumonti*, d'Archiac. Eocene: Baharia Oasis; and between Assiut and Qena, east side of hill.
30. *N. sub-Beaumonti*, De la Harpe. Eocene: Baharia Oasis; and between Assiut and Qena, east side of hill.
31. *N. discorbina*, Schlotheim. Eocene: Baharia Oasis.
32. *N. subdiscorbina*, De la Harpe. Eocene: Baharia Oasis.
33. *N. Gizehensis* (Forskål), Ehr., var. *Pachoi*, De la Harpe. Eocene: Baharia Oasis.
34. *N. curvispira*, Savi & Menegh. Eocene: Jebel Hamrawein and Baharia Oasis.
35. *Orbitoides* (*Discocyclina*) *dispansa* (Sow.). Eocene: Baharia Oasis.

EXPLANATION OF PLATE IV.

FIG. 1.—*Heterostegina*-limestone (*H. depressa*). Miocene: Wadi Dara, east of Red Sea Hills. No. 2,195, 1*h*. × 16.

FIG. 2.—Nummulitic limestone (*N. curvispira*). Mokattam Series: near Jebel Hamrawein, east of Red Sea Hills. No. 1,622, 56*h*. × 16.

FIG. 3.—*Operculina*- and nummulitic limestone (showing *O. complanata* var. *pyramidum* and *N. sub-Beaumonti*). Eocene: between Assiut and Qena, east side of Nile. No. 3,535, 52*l*. × 16.

FIG. 4.—Nummulitic and *Operculina* limestone (showing *N. discorbina*, *N. subdiscorbina*, and *O. complanata* var. *discoidea*). Eocene. No. E 1,480. × 16.

FIG. 5.—*Alveolina*-limestone (showing *Alveolina pasticillata* and *Valvulina Schwageri*). Eocene: Farafra Oasis (El-Guss-Abu-Said). No. 3,335*c*. × 16.

FIG. 6.—Nummulitic limestone with cavities filled with calcite, which were formerly occupied each by a nummulite. Eocene: Baharia Oasis. No. 3,348*g*. × 8.

EXPLANATION OF PLATE V.

Fig. 1.—*Bairdia Beadnelli*, sp. nov. *a*, view from right side; *b*, edge view; *c*, end view. Farafra Oasis. No. 3,335*b*. × 15.
Fig. 2.—*Bairdia minuta*, sp. nov. *a*, view from left side; *b*, edge view; *c*, end view. Farafra Oasis. No. 3,335*b*. × 15.
Fig. 3.—*Cythere Farafrensis*, sp. nov. *a*, view from left side; *b*, edge view; *c*, end view. Farafra Oasis. No. 3,335*b*. × 30.
Fig. 4.—*Placopsilina cenomana*, d'Orb. Farafra Oasis. No. 3,335*b*. × 30.
Fig. 5.—*Valvulina Schwageri*, sp. nov. *a*, the isolated test, lateral view; *b*, *c*, sections in vertical direction; *d*, transverse oral section. Farafra Oasis. Nos. 3,335*b* and *c*. × 30.
Figs. 6*a*, *b*.—*Bulimina elegantissima*, d'Orb., var. *seminuda*, Terquem. Farafra Oasis. No. 3,335*b*. × 30.

III.—On Kent's Cavern with reference to Buckland and his Detractors.

By Arthur R. Hunt, M.A., F.L.S., F.G.S.

In the Geological Magazine for September, 1901, I pointed out that Sir Henry Howorth had done Professor Huxley a great injustice in charging him with having suppressed certain important evidence. In the Magazine for January, 1902, Sir Henry, instead of hastening to acknowledge his error, proceeds to deepen his guilt by joining the pack that yelps at the heels of the great Dean Buckland.

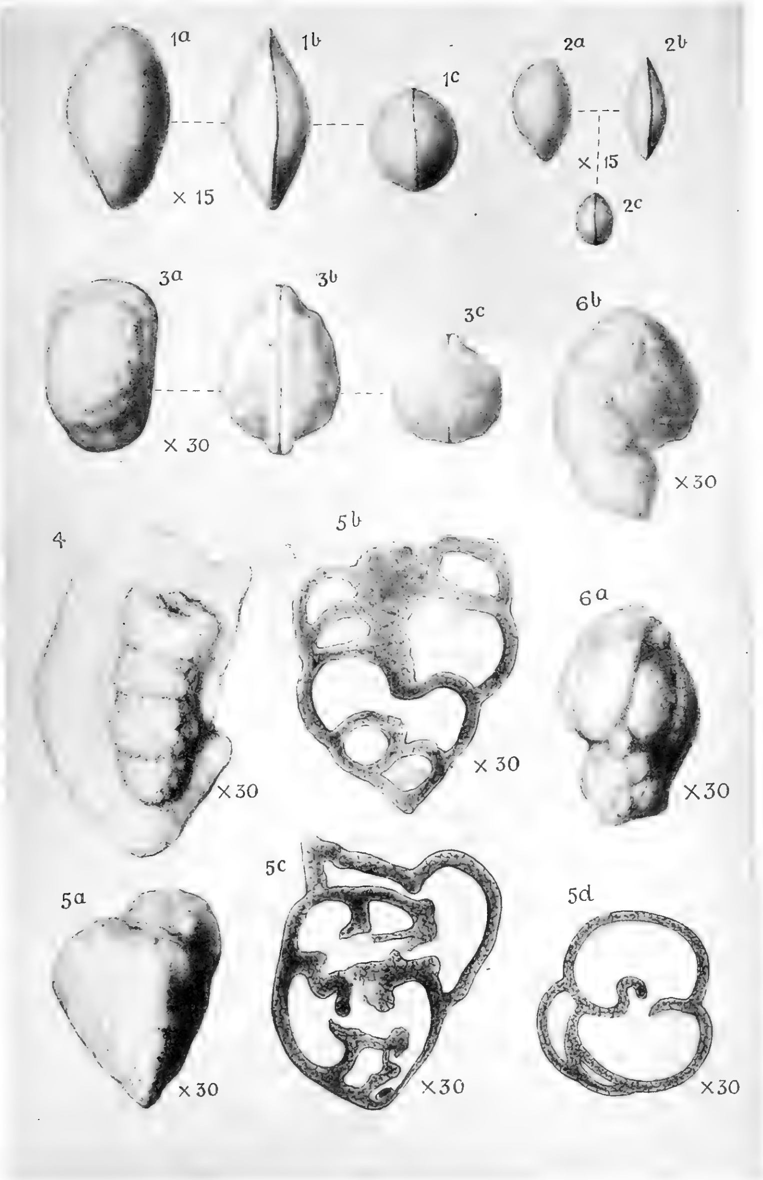
The one object of Buckland and the old cave-hunters was to reject a hundred facts rather than risk the acceptance of one error. Sir Henry shows clearly by his article that he would readily accept a hundred fallacies rather than run the risk of missing one fact. Let us take his three cases of Burrington, Wookey Hole, and Paviland, for each of which he censures Buckland, implicitly if not explicitly, e.g.—

Burrington. This is a cave in the Mountain Limestone with its mouth nearly closed by 'stalactite.' In it were bones encrusted by 'stalactite,' merely encrusted, not enclosed.[1] Sir Henry remarks, "It seems from our present knowledge almost certain that these bones belonged to Palæolithic man."

Some years ago, when exploring a cave on the coast of Galloway, my colleagues and self were desperately perplexed by portions of a human skull found under a mass of some 18 inches of stalagmitic breccia, capped by 2½ feet of practically pure stalagmite. Mr. W. Bruce Clarke, who wrote the final report on the cave, was inclined to dismiss the stalagmite as of no great importance, but kindly allowed me to record my dissent from that conclusion.[2] But the very utmost I could urge would be the time that has elapsed since the coastline has remained at its present level, as the cave seems to be a sea-cave of the existing period!

Our skull, under some four feet of breccia and stalagmite, was certainly not Palæolithic, and probably the merely encrusted Burrington bones were still more modern.

[1] Reliquiæ Dil., p. 164.
[2] Proc. Soc. Ant. Scot., 1878, p. 677.



OSTRACODA AND FORAMINIFERA FROM EOCENE LIMESTONES, EGYPT.

Among my notes collected during the exploration of the Borness Cave are the following extracted from the Proc. Soc. Ant., vol. iv, p. 111 :—

"Dowkerbottom Cave is on the high ground between Arncliffe and Kilnsay. . . . One of the coins found was under six inches of stalagmite. At this point the stalagmite was between five and six feet in thickness ; it was in layers, occasionally very hard, and then quite rotten and decayed. Some of the bones were buried deep in the stalagmite. . . . Three human crania in the cave . . . Goat, Dog, Horse."

This information is not precise enough for scientific purposes, and we are not even told the age of the coin. But we learn incidentally that the three coins found were of the reigns of Tetricus, A.D. 267–273, and of Claudius Gothicus, whose reign terminated in A.D. 270. These dates harmonized well with the main collection from the Borness Cave, though in my opinion the skull under the four feet of stalagmitic deposit must be much older, though assuredly not Palæolithic. According to Sir Henry Howorth's reasoning, we should have to accept both Claudius and Tetricus as Palæolithic men, and coinage as a Palæolithic art.

Wookey Hole. Here the teeth and fragments of bone were dispersed through reddish mud and clay, and some of them were united to it by stalagmite into a firm osseous breccia.[1] Sir Henry observes that as Buckland found a piece of a sepulchral urn among the bones, "this case is a doubtful one." Doubtful ! What could be more certain ?

Paviland. Sir Henry tells us that in this cave a female skeleton was found beneath six inches of earth, associated with two handfuls of shells of *Nerita littoralis* ; by which shell Buckland undoubtedly means *Littorina littoralis*, as he says it is common on the adjacent shore. Sir Henry continues, "We can hardly doubt with our present knowledge that these bones were those of a Palæolithic woman." On the contrary, Sir John Evans considers them those of a Neolithic man.[2]

In the cave were also found, according to Sir Henry, tusks of Mammoth ; but, according to Buckland, elephant. The distinction may be important.

If the skeleton and the elephant, together with hyæna and bear, were contemporary, England would be continental, and Paviland perhaps a hundred miles from the sea. In this case shells of *Littorina littoralis* would be somewhat out of place.

Moreover, we are told that the bones contained a small quantity of a yellow substance like adipocere, which is practically altered marrow. I should be inclined to submit that bones containing marrow associated with *Littorina littoralis* are as unlikely to be Palæolithic as any ancient bones could be.

With regard to the Liége caves, Schmerling (we are told) says that the human bones "agree in colour, in the degree of decomposition, and in the way they occur, with those of the extinct beasts. . . . ." Buckland, however, says, "The human bones found in these caves

[1] Rel. Dil., p. 165. [2] Evans' "Ancient Stone Implements," 2nd ed., p. 487.

are in a state of less decay than those of the extinct species of beasts."[1] This evidence is absolutely irreconcilable.

It is no object of mine to prove Buckland right or wrong, but I would ask any unprejudiced reader whether on the above evidence, and especially taking into account the momentous fact of $2\frac{1}{2}$ feet of stalagmite covering a skull in a cave of the present coastline—whether it would be worthy of a cautious scientist to accept such evidence as that of the caves of Burrington, Wookey Hole, Paviland, or Liége, as proof of the contemporaneity of man with the extinct animals. As any stick is good enough to beat a dog, so any myth seems sufficient to depreciate Buckland.

In the September number of the GEOLOGICAL MAGAZINE, Professor Rupert Jones writes: "The Rev. McEnery's reports on Kents Cavern were finished about 1826 . . . whilst McEnery's paper was supposed to be 'lost,' but really kept in the background by influence of the Rev. Dean Buckland. . . ." The fact is the Rev. J. McEnery never wrote a paper, nor reports. What he did write, viz. rough notes, were not finished in 1826; nor did Dean Buckland influence McEnery's decisions except by legitimate argument, which happened in McEnery's case to convince. McEnery's manuscripts were so truly lost that they were sold at auction with old sermons, and only recovered years later in a fragmentary condition. Parts are therefore still lost, a lamentable fact, beyond supposition.

The following are McEnery's own words:—

"On the 14th August, 1829, visited the cave accompanied by Master Aliffe." (Trans. Dev. Assoc., vol. iii, p. 295.)

"Vid. Buckland's resumé in reference to the discovery of human bones in Diluvium in Bridgewater Treatise. I cannot sum up better than with his remarks." (Trans. Dev. Assoc., vol. iii, p. 225.)

Then as to the cause of delay in publication of his works:—

"Had I not devoted so long a period to personal examination of all the circumstances attending this delicate question, in common with others I should have fallen into the error of supposing human remains to be contemporaneous because conjoined with the deposit of mud and bones. Into this opinion I fell at first from the discovery of flint blades in contact with both in several parts of the cavern and the alternation of the stalagmite, and I communicated my impressions to Dr. Buckland with all the earnestness of sincere conviction. It was to this doubt chiefly is owing the original delay in the publication of my labours. It is only from extended observation over the entire field of the cavern that I have come to the conclusion that human bones are long posterior to the sediment containing pebbles and bones, and that they date no more than half-way down from that period.

"If ever a temptation offered for passing the human skeleton for a *Homo diluvii testis* it is here, when accompanied by his weapons he is found mixed up in the Diluvium with the bones of elephant, etc.; but a regard to truth compels us to declare that all the attendant circumstances concur to the conclusion that his bones were deposited here by human hands to a period long posterior to the introduction of even the muddy sediment found in the cavern." (Trans. Dev. Assoc., vol. iii, p. 226.)

[1] Bridgewater Treatise, Buckland, vol. i, p. 598.

The importance of the differences of opinion between Buckland and McEnery have been greatly exaggerated. McEnery writes :—

"It is painful to dissent from so high an authority, and more particularly so from my concurrence generally in his views of the phenomena of these caves, which three years personal observation has in most every instance enabled me to verify." (Trans. Dev. Assoc., vol. iii, p. 338.)

The sole point here in dispute was the mode of accretion of stalagmite ; a question of the most profound indifference, as both Buckland and McEnery were agreed that the bones of men were absent from the 'Diluvium,' that the flint implements were introduced after the extinct mammalia, and that the flints were post the Noachian deluge. Where flints occurred under stalagmite Buckland contended that the stalagmite had been broken through and perhaps reformed. McEnery denied this, and maintained that the stalagmite was continuous and intact. But, as McEnery did not limit the rate of accretion, and believed the stalagmite was all posterior to the Noachian deluge, the difference of opinion is of no possible importance. Buckland and McEnery were equally mistaken ; and McEnery's error was perhaps more dangerous than Buckland's. The soundness of stalagmite is a question of inspection, whereas the rate of growth varies immensely. Were McEnery right as to the post-Diluvian age of the Kent's Cavern stalagmite, the cave would be no witness for the antiquity of man.

In 1840 Mr. Godwin-Austen wrote :—"Human remains and works of art . . . . occur throughout the entire thickness of the clay." (See Trans. Dev. Assoc., vol. ii, p. 498.)

In 1841 Dean Buckland maintained that "in Kent's Cavern . . . . the Celtic knives were found in holes dug by art, and which had disturbed the floor of the cave and the bones below it." (Quoted Rep. B.A., 1877, p. 55.)

In 1847 the Report of a Committee of the Torquay Natural History Society was submitted by Mr. E. Vivian to the Geological Society and to the British Association. Of the former Mr. Vivian writes in 1859 : The paper "was considered so heterodox that its insertion in the Transactions was delayed until the late lamented Dr. Buckland could again visit the cavern, which he was never able to accomplish" ("Cavern Researches," p. 60, note). The Council and Officers of the Geological Society included De la Beche, Lyell, Owen, Sedgwick, Forbes, Falconer, Murchison, and Darwin. But not Buckland.

In Section C of the British Association at Oxford it was reported that the undisturbed stalagmite three feet thick had been broken through in three places, and flint knives found in each instance. The President of Section C was Buckland.

Thus, at last, the great fact of Kent's Cavern was publicly advertised, under the auspices of Buckland, who did not, as did the Geological Society, postpone the publication for further enquiry.

Long after Buckland's death, the British Association spent sixteen years and nearly £2,000 in breaking up the stalagmite of Kent's Cavern, and removing the subjacent four feet of deposits. Hundreds of tons were taken out of the cavern, and with what result? So far as human bones were concerned, Buckland and McEnery were justified to the letter. Not a single human bone was proved from the cave earth (McEnery's 'Diluvium'). The human bones in the black mould of the cave were introduced by man, were not Palæolithic, and the cautious reasoning of the great explorers had saved them from what might have well been to them an everlasting blunder.

As to the flints, the two clerics were both mistaken. The flints were indeed coeval with the extinct mammalia, and they certainly were older than the reputed date of the Noachian deluge. What, then, can we fling in the face of these immortals? Just that they carried caution to excess—a vice which is better than most virtues.

Buckland and McEnery at any rate took a sane view of stalagmite and stone implements. They did not contend that the Kent's Cavern stalagmite entered in the form of a magma, or that the flints were not artificial, or that in a tunnel cave bones fell through the roof, or that Kent's Cavern was a mine in which that grand beast the hippopotamus (which never was in the cave) worked as a beast of burden. Yet all these things were gravely or even indignantly suggested to crush the unorthodoxy, scientific or theological, of the harassed explorers. But it has remained for the second year of the twentieth century to see an article in the GEOLOGICAL MAGAZINE on the Progress of the Modern Theory of the Antiquity of Man with no reference in it to the most important literature of the subject, the literature of Kent's Cavern.

IV.—NOTES ON THE ARENIG ROCKS NEAR ABERDARON, CARNARVONSHIRE.

By CHARLES A. MATLEY, B.Sc., F.G.S.

INTRODUCTION.

THE geology of the Lleyn peninsula has from time to time attracted the attention of geologists, and several workers have added much to our knowledge of this district; but their researches have been mainly confined to (1) the strip of ancient rocks (usually assigned to the pre-Cambrian) in the west between Porth Dinlleyn and Bardsey Island, and (2) the igneous rocks lying in the Ordovician ground which occupies the eastern and larger portion of the peninsula. Thus the Ordovician sedimentary rocks have largely escaped attention, a result probably also due to their monotony, to the rarity of fossiliferous localities, and to the great extent to which the beds are concealed beneath accumulations of drift.

It has long been known that in certain localities these sedimentary rocks are of Bala age, and that in other localities they belong to the Arenig series, but the general structure of the region remains obscure, for no serious attempt appears to have been made to work out the detailed stratigraphy of the area or to trace the various horizons zone by zone.

From the results obtained during a short visit to Aberdaron last summer the present writer is encouraged to think that such an attempt would meet with some measure of success. Fossils, though far from common, are not so rare, even in the Arenig beds, as has been generally supposed, and sufficient have now been found in the small area at present touched upon to show that it contains beds of Lower, Middle, and Upper Arenig age. The writer hopes to return to the district and continue the examination of the area, but meanwhile the following preliminary account summarizing the results so far attained may be of interest.

Area examined.

The Ordovician ground examined is a tract about four miles wide around the shores of Aberdaron and Llanfaelrhys Bays. A projecting outcrop of pre-Cambrian rock divides this area into two parts, a western portion abutting on Aberdaron Bay and an eastern portion adjoining Llanfaelrhys Bay.

Western or Aberdaron Tract.

The Ordovician beds here, except where bounded by the sea, are limited in all directions by faults which throw them against the pre-Cambrian rocks of the district. The general structure appears to be a syncline. Much of the ground is covered by thick masses of glacial drift.

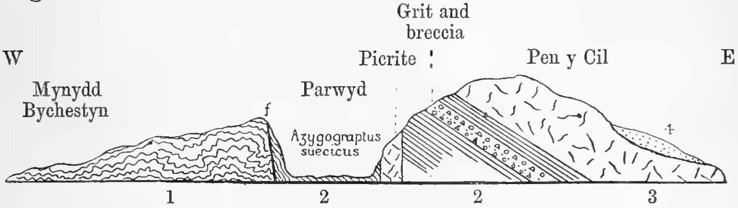


Fig. 1.—Section near Pen y Cil.

4. Drift.
3. Dolerite Sill.
2. Arenig rocks.
1. Pre-Cambrian.
f. Fault.

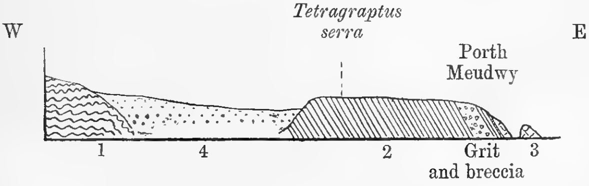


Fig. 2.—Section at Porth Meudwy.

On the western side of Aberdaron Bay we have the following sequence in descending order, as shown in Figs. 1 and 2 :—

(3) Dark shales surmounted by a thick sill of dolerite (Pen y Cil dolerite).
(2) Grit and breccia, forming a zone about 60 or 70 feet thick. The breccia contains abundant fragments derived from the pre-Cambrian region to the west.
(1) Dark slaty shales, usually hard and sandy, with numerous courses of fine sandstone.

The base of the succession is not seen. A specimen of *Tetragraptus serra*, Brongn. (= *T. bryonoides*, Hall), was found some 300 feet or so below the summit of (1).

Further north, in a small black-shale quarry near Aberdaron, a number of graptolites were obtained, probably *Didymograptus extensus*, Hall, and *D. nitidus*, Hall. Loose blocks found in the neighbourhood also yielded graptolites of the *D. extensus* type, though the actual species to which these forms belong have not been made out with certainty. They are very probably of Lower Arenig age.

Where the western boundary fault reaches the sea at Parwyd a mass of black shale with numerous flaggy bands of sandstone is wedged in between the pre-Cambrian rocks and a dyke-like mass of picrite which separates it from zone (1) of the above table. These Parwyd beds yielded *Azygograptus suecicus*, Moberg, and *Didymograptus*, sp., perhaps *hirundo*, and they represent a higher horizon than the beds with the 'extensiform' graptolites at Aberdaron.

The beds of the Aberdaron tract appear, therefore, to comprise rocks ranging from the Lower to the Middle and perhaps Upper Arenig. All the graptolites discovered are forms found in the "Middle Skiddaw Slates"[1] of the English Lake District.

Eastern or Llanfaelrhys Tract.

The rocks dip easterly, and consist of sandy and argillaceous shales, often containing flaggy and thick bands of sandstone. At various horizons in the series are injections of basic igneous rock, usually dolerite sills. Figs. 3 and 4 are sections across part of this area.

The succession is best observed along the coast, and may be stated in descending order as under :—

[Laccolite of Mynydd Penarfynydd, a mass of hornblende-picrite and hornblende-dolerite.]

(6) Penarfynydd shales with *Didymograptus bifidus*, Hall.

[Dolerite sill near Porth Llawenan.]

(5) About 6 feet of dark shale containing layers crowded with *Didymograptus bifidus*, Hall.

[One or more dolerite sills; coast obscured by drift.]

(4) Ironstone and manganese zone of Nant y Gadwen, comprising also concretionary blue mudstone and dark shales.

(3) Dark shales of Nant y Gadwen, characterized by *D. hirundo*, Salter. In these beds is a band that has been worked for manganese.

[Maen Gwenonwy dolerite sill.]

(2) Flaggy sandstones and sandy shales.

[Gallt y Mor dolerite sill.]

(1) A thick series of dark slaty beds, often sandy, and containing, especially in their lower part, courses of sandstone.

The base of (1) is not seen, being faulted against a strip of pre-Cambrian rocks.

Geologists are indebted to the late Mr. Tawney[2] for the first

[1] As defined by Miss Elles, Quart. Journ. Geol. Soc., vol. liv (1898), pp. 528 and 530.

[2] Geol. Mag., 1880, p. 211. Fossils, including graptolites, were also found in the neighbourhood of Llanfaelrhys by the Geological Survey; see Ramsay, Geol. North Wales, 2nd ed. (1881), pp. 215 and 377.

discovery of fossils in zone (6). The writer has not yet found 'tuning-fork' graptolites below zone (5). Both these upper zones are clearly of Upper Arenig or Llanvirn age. The ironstone and manganese band (4) is of stratigraphical interest, because it is found again about a mile away at Tyddyn-Meirion and at Benallt-bach, Rhiw. At the latter place these beds are worked commercially for manganese, and the blue concretionary mudstones there have provided specimens of *Azygograptus suecicus*, Moberg, and other fossils. The ironstone occurs in massive beds, and is of an altogether different character from the pisolitic iron-ore, supposed to be of Arenig age, found at Llanengan a few miles further east.

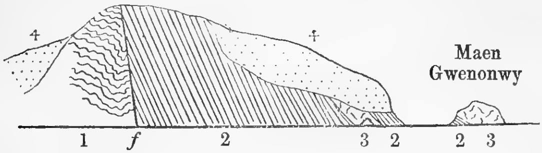


Fig. 3.—Section near Maen Gwenonwy.

4. Drift.
3. Dolerite Sill.
2. Arenig rocks.
1. Pre-Cambrian.
f. Fault.

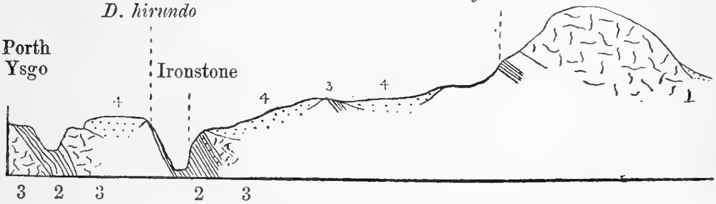


Fig. 4.—Section from Porth Ysgo to Mynydd Penarfynydd.

The lowest beds of this tract have not yet yielded fossils. They are possibly of Lower Arenig age, and they pass upwards, through Middle Arenig, into Upper Arenig beds. All the graptolites here recorded are forms which also occur in the Middle Skiddaw Slates.

Concluding Remarks.

The writer is indebted to Miss E. M. R. Wood for very kindly examining and identifying the graptolites and for information concerning their zonal value. Other fossils such as *Ogygia*, *Trinucleus*, *Lingula*, and *Orthoceras* have been obtained in several localities, but their species have not yet been worked out. The graptolites, however, show sufficiently well that the greater part of the Arenig is represented in the area described. The lowest beds of the series are cut out by faults; the beds leading up to the Llandeilo may be looked for in the country east of Rhiw.

Two points of interest remain to be briefly considered. The highly contorted, crushed, and complicated region to the west of Aberdaron has been spoken of in this paper as "pre-Cambrian," but the writer, in thus expressing the general opinion of geologists, does not thereby intend to exclude the possibility of some of the beds being of later age. The great difference of tectonic arrangement on opposite sides of the boundary fault is very striking. In comparison with the intense complication and the metamorphism of the "pre-Cambrian" region the Arenig rocks may be said to be practically undisturbed, and a strong impression of a great difference of age between the two sets of rocks is thus left upon the observer's mind. Direct evidence that this inference is well founded is now afforded by the rock-fragments occurring in the Arenig breccia of the western side of Aberdaron Bay. These fragments consist of pieces of schist, quartz-granulite, etc., unmistakably derived from rocks identical with many of those lying on the other side of the boundary fault, and their condition of alteration corresponds with the present stage of metamorphism of the latter. It is therefore clear that the metamorphism of this "pre-Cambrian" area had been practically completed not later than early Arenig times.

In this pre-Cambrian region patches of jasper are found associated with green basic igneous rocks. A similar association of rocks has been recently described as occurring along the eastern border of the Highlands of Scotland, where they have been designated the "Jasper and Green-Rock Series." On the grounds of their resemblance to the Arenig radiolarian cherts and lavas of the Southern Uplands of Scotland this Jasper and Green-Rock Series has been considered to be "most probably of Arenig age."[1] Whatever may be the merits of the case as regards the Highland Border rocks, it seems inadmissible to apply the same argument of analogy to the jasper-containing group of the Lleyn, in view of the quite distinct character and altogether different mode of occurrence of the undoubted Arenig rocks near by.

V.—Woodwardian Museum Notes: Salter's Undescribed Species. VI.[2]

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

(PLATE VI.)

PTEROPODA.

Conularia clavus, Salter. (Pl. VI, Figs. 1, 1*a*–*c*.)

1873. *Conularia clavus*, Salter, n.sp.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 153 (*a* 878).
1891. *Conularia clavus*, Woods: Cat. Type Foss. Woodw. Mus., p. 119.

The original specimen (*a* 878) is in a very perfect condition and comes from the Wenlock Limestone of Dudley. It also belongs to

[1] G. Barrow: Quart. Journ. Geol. Soc., vol. lvii (1901), p. 342.
[2] For previous articles see Geol. Mag., 1901, pp. 5, 106, 246, 355, and 576.

the Fletcher Collection. There is no other specimen of this species in the Woodwardian Museum. Salter calls it "a new square species."

DIAGNOSIS.—Shell forming a regular four-sided elongated pyramid. Sides equal, flat, except near aperture, where the middle of each face is slightly impressed, causing transverse section of aperture to be slightly quadrilobate. Transverse section below aperture square. Angles of pyramid marked by narrow groove. Aperture with margins inflected; lips of anterior and posterior faces large, semicircular, meeting in middle line; lips of lateral faces smaller, not so much infolded, not meeting in middle. Apex wanting, being broken off at transverse diaphragm. Faces of pyramid ornamented by 50–60 fine raised transverse ribs, angulated upwards along median line at obtuse angle of about 140° and set with small sharp equidistant tubercles, giving a moniliform appearance. The interspaces between the ribs are broad, flat, and smooth. The ribs of the adjacent faces are seen to alternate at the angles. There are 5 or 6 of these ribs on the anterior and posterior lips of the mouth, but only 1 or 2 on the lateral lips. There is no median longitudinal line down the centre of each face of the shell, nor any longitudinal ornamentation.

MEASUREMENTS.

Apical angle	20°
Rate of tapering	1 in 3
Width at mouth	5 mm.
Length (minus apex)	13·5 mm.

REMARKS.—This species belongs to Holm's[1] group *Moniliferæ* of the genus *Conularia*, and shows many points of resemblance to the species *C. monile* (Lindström),[2] but in the British form the tubercles on the transverse ribs are smaller, situated further apart, and not laterally compressed, and the ribs on which they are set are not placed so close together.

CONULARIA BIFASCIATA, Salter. (Pl. VI, Figs. 2, 2*a*.)

1873. *Conularia bifasciata*, Salter MSS.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 171 (*a* 926).

1891. *Conularia bifasciata*, Woods: Cat. Type Foss. Woodw. Mus., p. 119.

There is only the original specimen (*a* 926) of this species in the Woodwardian Museum. It comes from the Lower Ludlow beds of Leintwardine, and on the same slab are numerous specimens of *Monograptus leintwardinensis*. Salter says of this specimen, "only shows one face, and that of a young specimen." The thin shell is covered with irregular wrinkles owing to unequal compression.

DIAGNOSIS.—Shell large, pyramidal, apical angle 25°, of extremely thin substance. Surface marked by one small, straight, narrow median ridge, running longitudinally down the centre of the face. On each side of this ridge is a nearly parallel, narrow, dark line representing an internal septum. These two septa are straight and nearly parallel to each other, only slightly diverging in their course

[1] Holm, Sver. Kamb. Silur. Hyolith. o. Conular: Sver. Geol. Undersokn., ser. c, No. 112 (1893), p. 154.

[2] Lindström: Sil. Gastrop. Pterop. Gotl. (1884), p. 44, pl. i, figs. 9–12.

from the apex towards the apertural margin. Surface of shell ornamented by very fine, closely placed transverse lines, gently arched forwards parallel to the margin of the aperture, and closely set with microscopically minute oval tubercles, longitudinally elongated and arranged in regular longitudinal lines, giving a shagreen-like appearance to the shell. This ornamentation is not interrupted in the least in crossing the median ridge or the edges of the septa.

MEASUREMENTS.

Length	65 mm.
Width of aperture	22 mm.
Apical angle	20°

REMARKS.—The two Swedish Silurian species which very closely resemble *C. bifasciata* are *C. bilineata* (Lindström) and *C. aspersa* (Lindström).[1] Both of these possess the thin shell, the curious pair of septa in the middle of the face, and the same style of ornamentation. *C. bilineata* also shows traces of the small median ridge between the septa. The ornamentation of *C. aspersa* appears to resemble that of *C. bifasciata* most closely. But both the Swedish species differ in their apical angle, being much larger, i.e. from 30° to 35° instead of 20°. It is noteworthy that the specimen of *C. bilineata* described by Lindström (loc. cit.) is apparently preserved in much the same way as our specimen of *C. bifasciata*, for both have their extremely thin shell wrinkled and of a chestnut-brown colour.

HYOLITHES HOMFRAYI, Salter. (Pl. VI, Fig. 3.)

1873. *Theca Homfrayi*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 8 (*b* 263).
1891. *Hyolithes Homfrayi*, Woods: Cat. Type Foss. Woodw. Mus., p. 120.

This species is described by Salter (op. cit.) as "much longer than *Theca corrugata*." There are several specimens of this form in the Woodwardian Museum, one of the three original slabs labelled *b* 263 showing several individuals. Unluckily none are well preserved, and consequently the description of the species cannot be quite satisfactory. They come from the Menevian beds of Tyddyngwladis, and were presented by Mr. D. Homfray.

DIAGNOSIS. — Shell conical, elongated; apical angle 10°–15°. Face (ventral?) shows one longitudinal, narrow median ridge apparently accompanied by a slight infolding of the shell, with a lateral ridge on each side of it close to the margin of the face, apparently representing the inflexed margins of the dorsal face. In one specimen strongly marked growth-lines, arched forwards, cross the face between the lateral ridges, but outside these ridges their direction slightly changes. Aperture prominent, arched forwards. A distorted oval object near the mouth of the figured specimen may represent the operculum.

[1] Lindström: Sil. Gastrop. Pterop. Gotl. (1884), pp. 45–47, pl. i, figs. 4–8; pl. vii, figs. 1–3; pl. xix, fig. 1. Holm: Sver. Kamb. Sil. Hyol. o. Conul. (1893), p. 134, t. vi, figs. 38–42, 43–46.

MEASUREMENTS.	mm.	mm.
Length	25	37+
Width at aperture	5	?

REMARKS.—*Hyolithes Homfrayi* is closely allied to *H. bijugosus* (Salter)[1] from the Tremadoc beds. The apical angle, longitudinal keels, and prominent mouth are similar; but the stronger transverse striæ and the approximation of the lateral keels to the margin in *H. Homfrayi* are points of difference. It may be compared with the Swedish species *H. pennatulus* and *H. triumvir*,[2] but the material is so poor that this species of Salter's cannot be held to rest on a very firm basis.

HYOLITHES SULCATUS, Salter. (Pl. VI, Fig. 4.)

1873. *Theca sulcata*, Salter, n.sp.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 17 (*b* 322).

1891. *Hyolithes sulcatus*, Woods: Cat. Type Foss. Woodw. Mus., p. 121.

The two original specimens, *b* 322, which come from the base of the Upper Tremadoc of Llanerch, west of Portmadoc, and were presented by Mr. D. Homfray, consist of an internal cast and the impression of the same. Since the aperture is more or less broken and imperfect it is not possible to decide if it is the dorsal face of the shell, but I am inclined to think it is for reasons which are given below. Salter describes this species as "broad and short with longitudinal folds."

DIAGNOSIS.—Shell conical, broad, short; apical angle nearly 30°, trilobed, being divided into three elevated longitudinal ridges of approximately equal size by two sharply impressed angular grooves. The median ridge is rounded and convex; the lateral ones are angulated sharply down their centre. There are indications of several (four or five) small, rounded, longitudinal ribs running down the median ridge, and one or two less distinct ones on each of the lateral ridges. No transverse striation is present.

MEASUREMENTS.	mm.
Length	23
Breadth at front end	10

REMARKS.—In *Hyolithes bijugosus* (Salter) the convex side (which is called by Salter in this species the dorsal) is described as ridged with three distinct keels, the central one of which is the strongest, but the small apical angle (10°–12°) and the transverse lines of growth and absence of longitudinal ribs distinguish this species.

Hyolithes Billingsi,[3] from the Cambrian of Pioche, Nevada, resembles *H. sulcatus* more closely in having an apical angle of nearly the same size and the flattened dorsal side ornamented with three longitudinal ridges divided by furrows. The longitudinal ribs figured by Holm[4] in many Swedish species are found on the convex ventral side, but in those forms (*H. pennatulus*, *H. triumvir*, etc.) in which the edges of the dorsal face are folded round to the ventral

[1] Mem. Geol. Surv., vol. iii, 2nd ed. (1881), p. 559, pl. x, figs. 19, 20.
[2] Holm: Sver. Kamb. Sil. Hyol. o. Conul. (1893), t. iii, figs. 1–5, 6–11, etc.
[3] Walcott: "Fauna of the *Olenellus* Zone" (1890), p. 620, pl. lxxv, figs. 1, 1*a*–*c*.
[4] Holm: Sver. Kamb. Silur. Hyol. o. Conul. (1893), t. iii, figs. 1–5, 6–11, etc.

side the trilobation of the ventral face is very marked. The transverse striation is, however, a feature in these forms. The material at our disposal is not sufficiently well preserved to decide if *H. sulcatus* belongs to this latter group, called by Holm (op. cit., p. 154) *Magnidorsati*, subgroup *Carinati*, and it is even impossible to say positively if our specimens exhibit the dorsal or ventral face of the shell, though I am inclined from the resemblance to *H. bijugosus* and *H. Billingsi* to consider it to be the dorsal.

HYOLITHES TRILINEATUS, Salter. (Pl. VI, Fig. 5.)

1873. *Theca trilineata*, Salter MSS.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 18 (*b* 333).

1891. *Hyolithes trilineatus*, Woods: Cat. Type Foss. Woodw. Mus., p. 121.

Salter describes this form as "a small species with longitudinal lines." The original specimen comes from the base of the Upper Tremadoc, Moel-y-Gest, and was presented by Mr. D. Homfray. It is not in a very good state of preservation, and shows only the inner side of the dorsal face, but there are several other specimens from the Tremadoc beds of Tyn-y-llan, Portmadoc, which show the characters more distinctly.

DIAGNOSIS.—Shell conical. Apical angle 15°. Dorsal face provided with strong median longitudinal carina for two-thirds of its length from pointed apex. Anterior third of dorsal face flattened with prominent semicircular lip; carina obsolete on this portion of shell. Carina bordered by a sharp deep groove on each side which likewise die out in front. Between these grooves and the lateral edges of the dorsal face are faint indications of longitudinal ribs. On the anterior, flattened third of the shell two weak indistinct ribs may be distinguished, apparently not continued posteriorly towards the apex.

Faint transverse striæ, arched forwards, are present. (These are best shown on some of the Tyn-y-llan specimens in which the shell is preserved, but are visible also in the type-specimen.)

MEASUREMENTS:

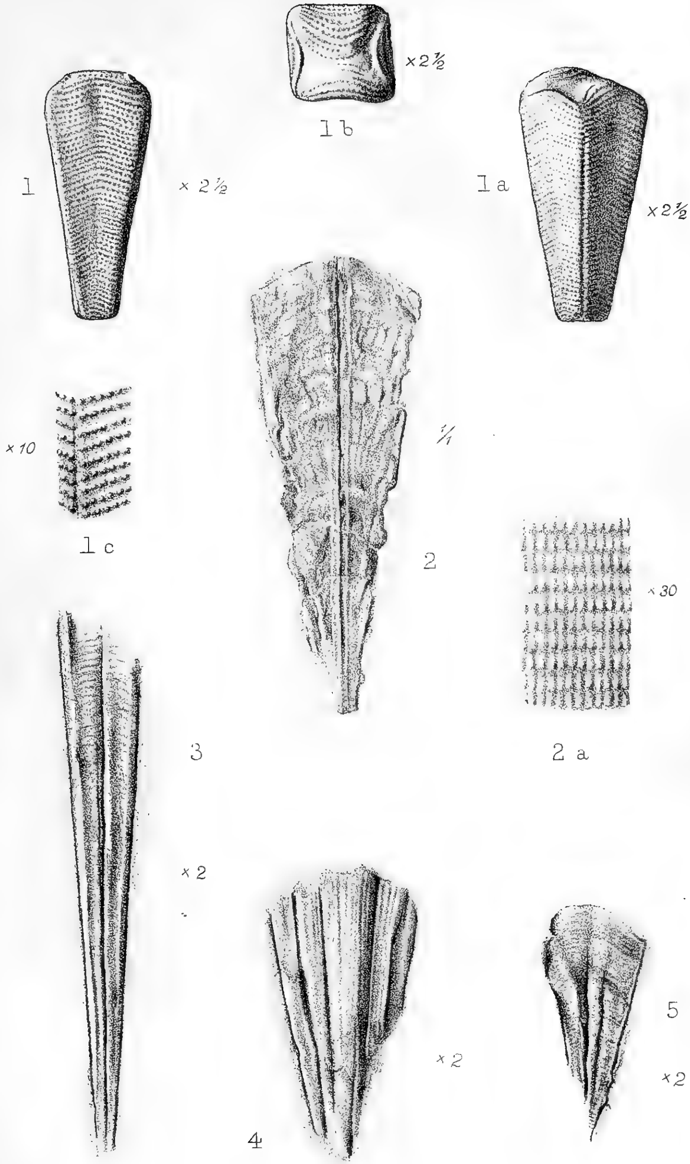
	mm.
Length	16
Width at mouth	6

REMARKS.—This species resembles *H. aratus* (Salter)[1] from the Lower (and Upper?) Tremadoc in the raised keel along the dorsal surface, the transverse arched striæ, and size of the apical angle, but differs in the reduction of the length of the keel and flattening of anterior portion.

EXPLANATION OF PLATE VI.

FIG. 1. *Conularia clavus.* × 2½.
,, 1*a*. Ditto, showing groove at angle. × 2½.
,, 1*b*. Ditto, mouth. × 2½.
,, 1*c*. Ditto, ornamentation. × 10.
,, 2. *Conularia bifasciata.* Nat. size.
,, 2*a*. Ditto. × 30.
,, 3. *Hyolithes Homfrayi.* × 2.
,, 4. *H. sulcatus.* × 2.
,, 5. *H. trilineatus.* × 2.

[1] Mem. Geol. Surv., vol. iii, 2nd ed. (1881), p. 559, pl. x, figs. 15, 21.



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

Palæozoic Pteropoda.

VI.—Note on the genus *Tmaegoceras*, Hyatt.

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

In a recent number of the "Neues Jahrbuch" (1901, Bd. ii, Heft 3, pp. 158–170, 6 text illust.) Dr. J. F. Pompeckj, of Munich, has an interesting paper on the genus *Tmaegoceras.* The genus was established by Hyatt[1] in 1889 for the two very rare Ammonites from the Lower Lias of the Alps, *Ammonites latesulcatus,* F. v. Hauer,[2] and *Arietites levis,* G. Geyer.[3] To these, in 1899, G. Bonarelli[4] added a third species, *Tmaegoceras Paronai,* from the Lower Lias of the Central Apennines, at the same time assigning to this genus Schafhäutl's *Ammonites Helli.*[5] But as Mojsisovics[6] pointed out in 1893, Schafhäutl's species is a *Tropites,* whilst *Ammonites latesculcatus,* F. v. Hauer, *Arietites levis,* G. Geyer, and *Tmaegoceras Paronai,* G. Bonarelli, have nothing whatever to do with that genus. Of these three species Dr. Pompeckj regards *Ammonites latesulcatus,* F. v. Hauer, and *Tmaegoceras Paronai,* G. Bonarelli, as generically identical, and with them he unites also Quenstedt's *Ammonites dorsosulcatus*[7] and his own new species (*T. crassiceps*[8]), which he describes from the Lower Lias (zone of *Arietites Bucklandi*) in the neighbourhood of Tübingen (Württemberg). He considers *Arietites levis,* G. Geyer, to be a true Arietite, probably related to *Arietites ophioides* (d'Orb.), Wähner,[9] or *Arietites Cordieri,* Canavari.[10]

As emended by Pompeckj the genus includes the four following species:—

1. *Tmaegoceras latesulcatum,* F. v. Hauer, sp. Lower Lias: Adneth, Bischofsteinbruch (Nordostalpen).
2. *Tmaegoceras dorsosulcatum,* F. A. Quenstedt, sp. Upper boundary of the Zone of *Schlotheimia angulata*: Vaihingen, near Stuttgart (Württemberg).

[1] A. Hyatt, "Genesis of the Arietidæ": Mem. Mus. Comp. Zool. Harvard Coll., xvi, No. 3 (1889), p. 125.

[2] F. v. Hauer, "Über die Cephalopoden aus dem Lias der nordöstlichen Alpen": Denkschr. Akad. Wissensch., Wien, Bd. xi (1856), p. 44, pl. ix, figs. 1–3.

[3] G. Geyer, "Über die liasischen Cephalopoden des Hierlatz bei Hallstatt": Abhandl. d. k.k. geol. Reichsanst., Wien, Bd. xii, No. 4 (1886), p. 252, pl. iii, figs. 10*a–c*.

[4] G. Bonarelli, "Cefalopodi Sinemuriani dell' Appennino Centrale": Palæontogr. ital., vol. v (1899), pp. 66–7, fig. 1.

[5] Schafhäutl, "Geognostische Untersuchungen des südbayerischen Alpengebirges," 1851, p. 107, pl. xv, fig. 21.

[6] E. v. Mojsisovics, "Die Cephalopoden der Hallstätter Kalke": Abhandl. d. k.k. geol. Reichsanst., Bd. vi, No. 2 (1893), pp. 201, 202, 207.

[7] F. A. Quenstedt: "Die Ammoniten des Schwäbischen Jura," p. 109, pl. xiii, figs. 33–35 (1885).

[8] J. F. Pompeckj, "Ueber *Tmaegoceras,* Hyatt": Neues Jahrb., 1901, ii, pp. 162–165, text-figs. 1*a–i*.

[9] Fr. Wähner: "Beiträge zur Kenntniss der tieferen Zonen des unteren Lias der nordöstlichen Alpen" (Beitr. zur Pal. Österr.-Ung., etc., Bd. vi, 1888), p. 164, pl. xxv, fig. 5.

[10] Fr. Wähner: op. cit., vi (Beitr. zur Pal. Österr.-Ung., etc., Bd. viii, Heft 4, 1891), p. 193, pl. xvii, figs. 1–4; pl. xviii, figs. 1–6.

3. *Tmaegoceras crassiceps*, n.sp. Zone of *Arietites Bucklandi*: neighbourhood of Tübingen (Württemberg).
4. *Tmaegoceras Paronai*, G. Bonarelli. Zone of *Arietites obtusus* (?): Ponte Grosso, near Ponte Alto (Central Apennines).

We note that in his paper Dr. Pompeckj makes no reference to Michelin's *Ammonites Lacordarii* [*airei*] [1] from the Lower Lias of France, and the object of the present note is to call attention to that species, because it seems to be related to Hyatt's genus.

Michelin's description of the species is as follows:—

"A. testâ discoideâ; infractibus 4–5, subinvolutis lævibus; lateribus convexis; canaliculatis propè penultimum anfractum; dorso carinato; carinâ parvâ, ad utramque partem altè canaliculatâ; aperturâ oblongâ, in medio depressâ.

"Làtit. testæ [= diameter] 90 millim.; latit. inf. ult. [= height of outer whorl] 30 millim.; latit. anf. penult. [= height of penultimate whorl] 20 millim.; latit. apert. [= width of aperture] 42 millim.; long. apertur. [= height of aperture] 30 millim.

"Cette espèce d'Ammonite, qui est fort rare, et dont je dois la connaissance à mon ami M. Lacordaire, ingénieur en chef du canal de Bourgogne, a été trouvée par lui dans des couches subordonnés du Lias, aux environs de Pouilly en Auxois, département de la Côte-d'Or. Elle est à l'état de moule intérieur, et ne paraît pas avoir eu une plus grande dimension, attendu qu'on ne voit la trace d'aucune cloison sur les trois quarts du dernier tour.

"La carène, se trouvant plus basse que les deux côtés extérieurs des canaux qui l'accompagnent, donne au dos de cette coquille l'aspect d'une corniche.

"Ma collection et celle de M. de Roissy."

The description is accompanied by three figures representing the lateral, apertural, and peripheral aspects of the type-specimen. The suture-line is not figured separately, but it is depicted in the lateral and apertural views of the fossil.

We have not seen an example of this rare species, nor do we know where Michelin's type is, but there is in the British Museum Collection [register number 37,150] a plaster cast of the type-specimen, and it seems to us most probable that the species belongs to Hyatt's genus *Tmaegoceras*. To the dimensions given above it may be added that the width of the umbilicus is 40 mm. Michelin's figures give a very good idea of the general form of the specimen, but the suture-line, though probably well shown on the fossil, does not appear to be at all accurately drawn. The suture-line has not been reproduced on the cast. The general form of the species appears to come very near Pompeckj's new species *T. crassiceps* and Bonarelli's *T. Paronai*, and the suture-line, according to Michelin's figure, certainly suggests the characters of that of Von Hauer's *Ammonites latesulcatus*, the type of *Tmaegoceras*, rather than that of an *Arietites*.

[1] H. Michelin: Mag. de Zool., v (1835), Classe 5, pl. 67.

VII.—Some Railway Cuttings in Suffolk.

By Horace B. Woodward, F.R.S.

1. *Yarmouth and Lowestoft Direct Railway.*

YARMOUTH and Lowestoft have long been connected by railways, but although the Great Eastern Company had provided a choice of routes, there was no direct way. This is now in process of construction by a joint arrangement between the Great Eastern, Great Northern, and Midland Railway Companies; and the route, for the most part within a mile of the sea-coast, is from the Great Eastern Station at Lowestoft through Gunton, Hopton, Corton, and Gorleston to the Yarmouth Beach Station, a distance of a little more than nine miles.

Where the new railway leaves that of the Great Eastern Company, about half a mile west of the Lowestoft Station, there is a cutting in buff, false-bedded, slightly gravelly sand belonging to the Middle Glacial Drift. Further on, Boulder-clay was cut into, to the east of Normanston Court, and it has there been burnt for ballast. A few glaciated Belemnites were noticed, but derived fossils were not so plentiful as in some other localities.

South of St. Margaret's Church and east of Normans Hurst the junction of the Boulder-clay with underlying Middle Glacial sand was well shown in the railway cutting on the north side of the road. The Boulder-clay contained much chalk and many flints and galls of sand, and it rested on buff sands. At the junction a good deal of sand was incorporated with the Boulder-clay, and the sand was streaked with chalky detritus. The sand below was exceedingly fine.

East of St. Margaret's Church, sand and pebbly gravel (Plateau Drift) were exposed, while to the north of the main road to Corton, beyond Belle Vue Park, a wide excavation for the railway-station showed the following sequence:—

			ft.	in.
Soil with much blown sand		1 ft. to	1	6
Plateau Gravel	Yellow sand		0	9
	Pebbly gravel		4	6
Middle Glacial	Fine false-bedded sand and gravel		1	6
	Sand with streaks of loam		4	6

The pebbly gravel consisted chiefly of flint and quartz, with a few large blocks of flint and yellow micaceous sandstone. In one part it rested irregularly on the beds below, cutting into them, while elsewhere there appeared absolute conformity. Such a section suggests that when one gravel is deposited on top of another, and perhaps largely constructed from it, it may be so welded on to it that all evidence of break is obliterated.[1]

Further on to the north of Corton Long Lane, a cutting showed sandy and gravelly soil on stiff loam and Chalky Boulder-clay, the loam being in part decalcified Boulder-clay, but not wholly so. In the Boulder-clay at Corton, there were irregular masses of yellowish

[1] See also Geol. Mag., 1902, p. 30.

and reddish brown sand, coarser than the sand which locally underlies it, and containing angular flints and many flint pebbles. This did not lie in eroded hollows, but was evidently incorporated in the Boulder-clay. The sand was slightly indurated, and, in dry weather, it had separated from the Boulder-clay, and broken away in smooth dogger-like masses, which, however, merged upwards into the loam or decalcified Boulder-clay. (Fig. 1.)

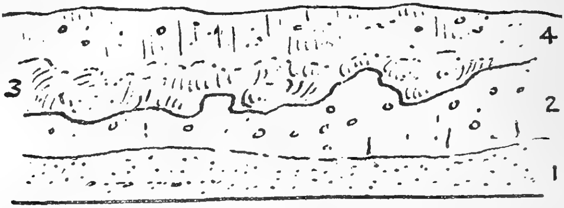


FIG. 1.—SECTION WEST OF CORTON.
4. Boulder-clay. 3. Indurated sand. 2. Boulder-clay. 1. Middle Glacial Sand.

Near St. Bartholomew's Church, at the junction of the Boulder-clay with the underlying buff sand, a thin pan of ironstone occurred, and here and there fine chalky detritus was present in the sand. Buff sand was also incorporated at the base of the Boulder-clay, while the portions beneath, to a depth of two feet, showed distinct evidence of disturbance. (See Fig. 2.) The Boulder-clay here contained septaria, ironstone nodules, and Jurassic fossils, also fragments of Red Chalk.

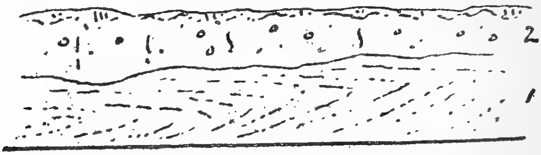


FIG. 2.—SECTION NEAR ST. BARTHOLOMEW'S CHURCH, CORTON.
2. Boulder-clay. 1. Middle Glacial Sand.

South of Hopton there was a cutting in Boulder-clay with here and there at the base coarse sand, which was slightly indurated at the junction and merged downwards into fine current-bedded buff sand. This coarse sand was stained red and precisely like the masses elsewhere incorporated in the Boulder-clay. Here, again, the sands below the Boulder-clay were distinctly contorted, and in places where the junction was less even. At one spot the sand contained scattered pieces of a broken ochreous band. (Fig. 3.) Elsewhere, between Boulder-clay and sand there was a layer of unctuous clay and loam streaked with chalky detritus.

North of Hopton the cutting showed 10 feet of sand and gravel, and beyond Kennel House brown and white sand belonging to the Middle Glacial Drift, overlaid by 5 to 8 feet of angular and pebbly Plateau gravel. This gravel was bleached and contained many unworn flints, as well as pebbles of flint, quartz, etc.

In the long cutting at Gorleston fine sections were to be seen of false-bedded gravelly sand with worn fragments of *Cyprina, Cardium,* and other derived shells, and on top of this drift there was a patch of Boulder-clay to the south-west of St. Andrew's Church.

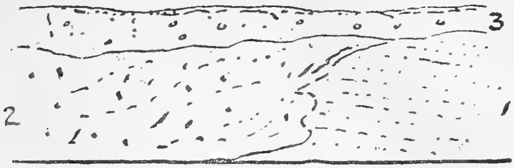


FIG. 3.—SECTION SOUTH OF HOPTON.
3. Boulder-clay. 2. Middle Glacial Sand with broken ochreous band. 1. Middle Glacial Sand.

Beyond Gorleston the railway traverses the marshland below Breydon Water, and terminates on the Blown Sand and Shingle to the north of Yarmouth.

2. *Cutting at Halesworth.*

The widening of the Great Eastern Railway just north of Halesworth Station opened up during June of last year (1901), a fine section of the Chalky Boulder-clay with an included mass of chalky and flinty gravel and seams of clay. At the northern end of the cutting, which was made on the eastern side of the railway, the Boulder-clay contained nests of brown and fine white sand, also a mass of shattered chalk; and it presented its usual characters of stiff blue clay with many glaciated pieces of chalk

FIG. 4.—SECTION AT HALESWORTH STATION.
Chalky Boulder-clay with included gravelly bed.

and septaria, unrolled flints, fragments of Red Chalk, Kimeridge Shale, and numerous Jurassic Ammonites and Belemnites.[1] Of most interest was the gravelly mass (Fig. 4), which was made up as follows:—

	feet.
Brown loamy and chalky gravel	4 or 5
Slightly indurated clayey and marly band with flints, and fragments of shale	$1\frac{1}{2}$
White and buff sand with chalk grains, and seams of chalky and flinty gravel	5 or 6
Brown stony clay	2
Very fine sand	1
Chalky and flinty gravel	7 or 8
Brown marly clay	$\frac{1}{2}$

The gravelly beds contained numerous pebbles of chalk, many black flint pebbles, and pebbles of quartz and quartzite, as well as

[1] A collection of the fossils has been made by Mr. Charles Ganz, of Aldborough.

angular flints and broken flints. Such a deposit was evidently formed by a stream due to melting of the débris-laden ice, and its chalky constituents have been preserved owing to the protection afforded by the Boulder-clay, for as a rule the Glacial gravels are decalcified.

It is from beds of this nature in the Boulder-clay that supplies of water are sometimes met with by well-sinkers.

The cutting extended about 15 chains, and in its highest part was about 25 feet above the rails.

NOTICES OF MEMOIRS.

I.—The Gold Fields of Wainad, in Southern India. By H. H. Hayden, B.A., F.G.S., and F. H. Hatch, Ph.D., F.G.S. Memoirs of the Geological Survey of India. 8vo; vol. xxxiii, pp. 48, with seven plates. (Calcutta, 1901.)

THE Geological Survey of India have issued a memoir dealing with the goldfields of Wainad in the Malabar District. Mining operations having been recently abandoned as unproductive, and reports by previous experts on their value being conflicting, a more exhaustive mineral survey than any hitherto undertaken was made by Mr. H. H. Hayden and Dr. F. H. Hatch, the services of the latter as a mining specialist being temporarily secured by the Indian Government. Typical reefs having been selected, their systematic examination was proceeded with, and numerous specimens obtained at fixed intervals were analyzed at Calcutta. The results of the analyses, averaging about 2 dwt. of gold to the ton, are disappointing, and corroborate the opinion formed on the ground that the grade of ore is too low to justify the further exploitation of the district. The region furnishes a striking example of the unreliability of old native workings as a safe criterion of the existence of payable metal. With the employment of forced labour along surface outcrops and the use of primitive machinery the cost of production is necessarily reduced to a minimum, and the popular idea that the crude methods of the ancients necessitated the presence of high-grade ore is a fallacy that should be taken to heart by investors in other parts of the world at present under exploitation. J. B. H.

II.—Perim Island and its Relations to the Area of the Red Sea. By Catherine A. Raisin, D.Sc.[1]

THIS paper describes briefly rock specimens from Perim Island collected and placed at the disposal of the authoress by Captain J. A. Rupert Jones, now stationed at Aden.

The island, as shown in the Admiralty chart, has somewhat of a horseshoe shape, enclosing a harbour opening to the south. Low plains, less than 12 feet above sea-level, extend in from the coast, especially at the north, and consist of raised beaches, but most of the southern and eastern parts are hilly, reaching 249 feet at the highest point.

[1] Read before the British Association, Section C (Geology), Glasgow, Sept., 1901.

The specimens sent are all from volcanic rocks. The surface, according to Captain Rupert Jones, is composed mostly, to a depth of about 7 feet, of loose blocks (4 feet or less in diameter), often imbedded in calcareous sand or mud. The underlying rock is exposed in cliffs and in quarries, and occurs generally in roughly horizontal layers. One mass *in situ* (near Balfe Point) is a not very basic basalt (almost an andesite) crowded with felspar microliths with marked fluidal orientation, and is probably a lava-flow. Another reddish rock with scattered rounded vesicles (from a cliff north-east of the harbour) approaches a microcrystalline basalt in character, and consists of much plagioclase, clear gum-like augite, some red-brown ferruginous olivine or pyroxene, and a little black speckled glassy base. In another spot (near Balfe Point) a whitish tuff or fine agglomerate is quarried, and consists largely of fragments of pumice with some broken felspar, augite, and other crystals.

The surface blocks in one or two examples consist of fragmental rocks. One is a red, more basic tuff, containing thin black streaks, apparently of a spherulitic glass. The blocks, however, are mostly scoriaceous and vesicular, petrologically generally basaltic, and similar to the underlying rocks described above, but with some variation, as if they might represent a broken lava crust. They are crossed by veins of calcite, and the ashy materials and other fragments are often cemented by calcareous deposits.

The history of Perim Island belongs mainly to the Tertiary era. We may infer that the Red Sea, from its general contours and the steep descent of the bed towards a central depression, forms part of the Great Rift Valley, extending from Lake Tanganyika to the Jordan, along which at so many places volcanic outbursts on a large scale have occurred. Both in Arabia and in Abyssinia extensive tracts of volcanic rocks are found of more than one period. The rocks of Perim belong probably to the later or so-called Aden group. The raised beaches of the island are an evidence of oscillations of level, which are proved by upraised and submerged coral reefs to have affected other parts of the Red Sea. Denudation and weathering of the surface took place, and calcareous sediment was deposited, while at different times coral reefs became established in the adjacent shallow seas.

REVIEWS.

I.—Catalogue of the Fossil Fishes in the British Museum (Natural History). By Arthur Smith Woodward, LL.D., F.R.S., F.G.S. Part IV: pp. xxxix, 636, with 19 Plates and 22 Figures. 8vo. (London, 1901.)

DR. A. SMITH WOODWARD and the British Museum are to be congratulated on the completion of this important memoir on Fossil Fishes, the fourth volume of which has been for long anxiously expected by all Ichthyologists. For those specially at work among the fossil forms, it will be a welcome and an indispensable aid. We have no other modern book dealing in detail with the whole group of Fossil Fishes, from all parts of the world; and as a work of reference these four volumes may be regarded as a companion of the "Recherches sur les Poissons Fossiles," by Louis Agassiz, which was completed in 1843. The simple and unostentatious title of "Catalogue" under which Dr. Smith Woodward's work is published is misleading. It is true that it includes a catalogue of the British Museum Fossil Fishes, but it is much more than appears from the title: it is a critical revision of this interesting but difficult assemblage of fossils, bringing together the work of the last fifty years, which has been scattered through various publications in all parts of the world. Moreover, to each species, genus, and larger group characteristic descriptions are given, as well as their synonyms, and this renders the so-called "Catalogue" a memoir of the Fossil Fishes which will be of permanent value, and cannot fail to be the work of reference for a long time to come. The British Museum possesses an unrivalled series of fossil fishes, accumulated during many years, and including several well-known and valuable collections. Free access to such an extensive collection was a necessity before a task, like that undertaken by Dr. Smith Woodward, could be entered upon with any hope of success; but in the work now before us the author has shown how fully he has been able to take advantage of these materials, by producing a memoir which is an honour to himself and to the institution under whose auspices it is published.

It is now twelve years since the first volume was issued, the second volume appearing in 1891, and the third volume in 1895; each of these being noticed in this Magazine.[1] Now, after an interval of six years, we welcome the fourth volume, which completes the work.

The first volume is entirely devoted to the fossil Elasmobranchii, the Sharks and Rays as we ordinarily understand them, and is thus complete in itself; but the fishes with shagreen-like scales and spines to their fins, known as the Acanthodii, seem to bridge over the gap between ordinary Sharks and certain forms that were formerly classed as ganoids. Although the Acanthodii are included by Dr. Smith Woodward in the Elasmobranchii, yet he has found it convenient to place them at the beginning of his second volume, which also contains the Holocephali (Chimæroids), the Ostracodermi (*Cephalaspis* and *Pteraspis*), the Dipnoi (*Coccosteus, Dipterus, Ceratodus*, etc.), and a part of the Teleostomi. The last-named subclass embraces all the ganoids not included in the above-mentioned groups, as well as the true bony fishes or Teleosteans. The Teleostomi are divided by Dr. Smith Woodward into the Crossopterygii, or those fishes with lobed or fringed fins, and the Actinopterygii, those with ordinary non-lobed fins. The Crossopterygii are treated of in the second volume, as well as the Palæozoic Actinopterygii belonging to the Chondrostei, namely, *Palæoniscus, Platysomus*, and their allies. The third volume is practically an

[1] See Geol. Mag., 1889, p. 366; 1891, p. 132; and 1896, p. 124.

account of the Jurassic ganoids, or those Actinopterygian Teleostomi that were dominant during the deposition of the first half of the Secondary rocks, and includes such genera as *Chondrosteus*, *Semionotus*, *Lepidotus*, *Dapedius*, *Eugnathus*, *Pachycormus*, and *Pholidophorus*. Many forms of Pycnodonts are described both from Jurassic and Cretaceous rocks, while *Lophiostomus* and *Protosphyræna* are representative genera of Cretaceous age. *Amia* and *Lepidosteus* are Tertiary types of these fishes which have continued to exist to the present day.

The fishes which remain for consideration are just those which have for so long been known as Teleosteans, or true bony fishes, and the fourth volume of the work, now published, is really an account of the Bony Fishes of the Cretaceous and Tertiary formations.

The present volume begins with Isospondylous Actinopterygii; that is, those fishes with non-lobate fins, which have vertebræ more or less ossified, without indications of pleurocentra or hypocentra, and having none of them fused together; the lower jaw also is formed of only two or perhaps three distinct bones. The three families of these fishes which have the closest affinities with the old-time ganoids, were included with those forms in the previous volume.

Among the remaining families of the Isospondyli are to be found many remarkable genera of Cretaceous bony fishes; and these, with the other suborders, may now be considered more in detail. The Isospondyli include among them the Elopidæ and Chirocentridæ, which are "the most important Cretaceous families of primitive bony fishes"; they were at that period particularly abundant and widely distributed, and a few of their descendants are living at the present day. The Elopidæ are of especial interest, inasmuch as they retain the *gular plate*, so characteristic in Jurassic fishes, and here appearing for the last time; indeed, in some of the genera it is quite rudimentary. *Isteus* is a noteworthy genus, on account of its close relationship with the living deep-sea *Bathythrissa*.

In the Cretaceous period were many and striking forms allied to the living but primitive *Chirocentrus*; among these may be mentioned the giant *Portheus* of North America, which is represented also in this country by more than one species. The well-known *Saurodon* and *Saurocephalus* are likewise members of this family, and Dr. Smith Woodward regards the *Thrissops* of the Upper Jurassic as a near ally.

Some years ago, it will be remembered, the reptilian jaw which Owen called *Mosasaurus gracilis*, now in the Brighton Museum, was relegated to the piscine genus *Pachyrhizodus*, of the family Elopidæ; it is pleasing, therefore, to know that a renewed examination of the type shows the correctness of Owen's determination, and that this specimen is to return to its place among the Mosasaurian reptiles.

True Clupeoids are well represented in the Cretaceous rocks, "and their skeleton is so closely similar to that of the typical Jurassic Leptolepidæ that they may well be direct descendants of the latter. . . . . Most of the Cretaceous forms are typical Clupeidæ, and they have scarcely changed during subsequent epochs. A few, however, discovered only in the Cretaceous rocks, are of especial interest as exhibiting the precocious development of a character, namely the pelvic fins near to the pectoral arch, which was never permanently acquired by fishes with so primitive a skull, but soon became the common feature of the spiny-finned or acanthopterygian families." These aberrant forms have another interest for geologists who have made the Chalk their special study. These precocious herrings, if we may so call them, are none other than the characteristic fishes of the Chalk, which we have all along known as *Beryx*, or rather it is that portion of them left to us after Dr. Smith Woodward had, about twelve years ago, removed some of the species to the genus *Hoplopteryx.* But now we learn that our supposed Cretaceous representatives of the deep-sea *Beryx* are little more than common herrings, and do not even belong to the family of the Berycidæ; they have been renamed *Ctenothrissus,* and placed in a new family, the Ctenothrissidæ. *Beryx,* it is said, is not certainly known as a fossil. The Chalk without *Beryx* is almost like "Hamlet" without the central figure. Much as we may regret this change of names, we must, even while smarting under the correction, appreciate the acumen which has detected the form of the lowly herring under the guise of the highly specialized *Beryx,* and be thankful for the elimination of a fundamental error.

Dr. Smith Woodward says that these Ctenothrissidæ are essentially Clupeoids with the pelvic fins displaced forwards and situated nearly under the pectorals. If this be so it is a remarkable fact, and not a little difficult to understand why these should have become extinct, while other fishes, which underwent a similar modification during the Cretaceous era, have retained it until the present day and have become a predominant race.

The true family of the Clupeidæ does not seem to be represented in British Cretaceous rocks, although occurring in deposits of that age in other parts of the world; it is especially abundant in the Upper Cretaceous beds of the eastern Mediterranean. In Tertiary times, however, these fishes were certainly living in the British area and had an almost worldwide distribution.

The Decertidæ, those remarkable elongated fishes with longitudinal rows of paired scutes with which we are familiar in the English Chalk, are known only from beds of that age, but had then a wide distribution. "They are interesting as being the earliest type of fish in which evidence of a distensible stomach has been observed."

The well-known *Enchodus* and its allies, which are exclusively Cretaceous fishes, are variously specialized by the development of large teeth and dermal scutes. The author thinks that this family may have furnished the ancestors not only of the Berycidæ but also of the Scopelidæ.

The family Esocidæ, with its only genus *Esox,* is also included in the suborder Isospondyli; it is sparsely represented in later Tertiary beds, and fragments of fishes, which cannot be distinguished from the common pike, *Esox lucius,* are met with in Pleistocene deposits.

The fresh-water Siluroid and Cyprinoid fishes, which are the chief forms included in the suborder Ostariophysi, are not known until the Tertiary period, but the remains met with in the Lower Eocene are highly specialized, and one Siluroid, at least, cannot be separated from the living *Arius*.

The Eels, which are comparatively primitive fishes, showing in many points degenerate specialization, are represented in the Cretaceous rocks by forms displaying most of their peculiarities, except the absence of the caudal fin. Dr. Smith Woodward thinks these fishes could not have been derived from any known form of Teleostean, but must have been directly descended from some Mesozoic ganoid form.

Nearly all the Cretaceous Acanthopterygian fishes are referable to the Berycoids and Scombroids, and it is among these that the oldest true Acanthopterygian fishes are found. The Upper Cretaceous genera are said to be but little specialized, "and it seems probable that they actually originated at about the period of deposition of the Chalk of the northern hemisphere." *Hoplopteryx*, the genus to which certain species formerly called *Beryx* are now referred, is remarkable for the excessive development of the mucous cavities about the head.

The presence of what seems to be a true Percoid fish in the uppermost Cretaceous of France leads Dr. Smith Woodward to infer that many such forms existed during that period, but they still remain undiscovered. Scombroids and Berycoids are found in Tertiary deposits, and "the principal types had already appeared early in the Eocene period; and among these fishes there are many which cannot be distinguished by their skeletons from genera which still survive." Cod-fishes and flat-fishes date back to the Oligocene and Upper Eocene, but no generalized ancestor has been recognized.

Dr. Smith Woodward tells us that "as soon as fishes with a complete osseous endoskeleton began to predominate at the dawn of the Cretaceous period, specialisations of an entirely new kind were rapidly acquired. Until this time the skull of the Actinopterygii had always been remarkably uniform in type. . . . . The pelvic fins always retained their primitive remote situation, and the fin-rays never became spines. During the Cretaceous period the majority of the bony fishes began to exhibit modifications in all these characters, and changes occurred so rapidly that, by the dawn of the Eocene period, the diversity observable in the dominant fish-fauna was much greater than it had ever been before. At this remote epoch, indeed, nearly all the great groups of bony fishes, as represented in the existing world, were already differentiated, and their subsequent modifications have been quite of a minor character."

The author had evidently hoped that the detailed study of the Cretaceous and Tertiary bony fishes would have thrown greater light on the origin of modern forms, for he says "the result, however, is much less satisfactory than might have been expected from the study of animals which lived under conditions most favourable for their preservation as fossils. The circumstance that a very large proportion of the Tertiary fishes are known only from detached otoliths, suffices to indicate the extreme imperfection of the geological record in their case."

The comparatively meagre materials, where so much was to be expected, lead the author to say further that "Palæontology has, indeed, hitherto revealed as little concerning the origin of the dominant Tertiary fishes as of the Tertiary mammals."

This seems a somewhat extreme view after Dr. Smith Woodward has shown us so many affinities between the Cretaceous and more modern fishes, and is perhaps to be read rather in the light of his own larger expectations than as a conclusion to be drawn from the premises he has himself laid before us in these volumes. To make the cases of the Fishes and the Mammals parallel, the gap between the Tertiary and Mesozoic fishes should have been at least as great as that between Teleosteans and Sharks. But whatever may be our views as to the light thrown by Cretaceous fishes upon the origin of the more highly developed forms of the Tertiary period, there can be but one opinion as to the extreme value of the work accomplished by Dr. Smith Woodward among fossil fishes, the results of which are embodied in these four volumes.

Of the 19 plates which illustrate this volume 18 have been drawn by Miss G. M. Woodward, with the usual excellent result. There are perhaps no more difficult objects to draw than fragmentary fossil fishes, and an examination of these plates shows the extreme care which has been bestowed upon them. We are told that the instructive restorations in the text are by the same lady's hand; but there are other text figures the origin of which is not stated. The figures on plate xvii are evidently reproductions from photographs, and are admirable representations of the fossils.

In the preface, which old friends will be pleased to see signed by Dr. Henry Woodward, we are told that already there is a necessity for a supplementary volume. E. T. N.

II.—The Water Supply of Berkshire from Underground Sources. By the late J. H. Blake, F.G.S., with contributions by William Whitaker, F.R.S. Memoirs of the Geological Survey. 8vo; pp. 115. (London: printed for H.M. Stationery Office, 1902. Price 3s.)

TWO years ago attention was drawn to the publication of a memoir on the Water Supply of Sussex, and the present work may be regarded as a companion volume. There is a general account of the strata, with special reference to their water-bearing capacities; there are records of numerous borings in Berkshire, and some analyses of the waters are given. The work should prove of great service to those in search of a supply of water in the county, and even 'diviners' might find the information not without value. The records of the borings will also prove useful to those who are studying the varying characters and thicknesses of the strata, and the underground geology so far as it is known. Nowhere at present have Palæozoic rocks been reached in Berkshire.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—January 22nd, 1902.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read :—

1. "The Fossiliferous Silurian Beds and Associated Igneous Rocks of the Clogher Head District (County Kerry)." By Professor Sidney H. Reynolds, M.A., F.G.S., and Charles I. Gardiner, Esq., M.A., F.G.S.

After a brief account of the bibliography of the district, the authors proceed to give a detailed description of the coast from Dunquin past Clogher Head to Coosglass (south of Sybil Point), and of the western side of Smerwick Harbour. They next deal with the inland exposures, which are not very frequent, but include considerable rock-masses at Croaghmarhin and Minaunmore Rock. The rocks consist of sandstones, slates, calcareous flags, ashes and ashy conglomerates, rhyolitic lava-flows, and various intrusive rocks. The general structure is an S-shaped fold, inverted towards the north so that the dip of the beds is approximately south-easterly, and the oldest beds occur to the north, at Coosglass. Both anticline and syncline are faulted, and a patch of Old Red Sandstone is caught in under the synclinal thrust at Coosmore. Fossils, mainly corals, brachiopods, lamellibranchs, and gasteropods, are fairly abundant; but trilobites are rare and graptolites absent. The whole of the fossiliferous rocks are of Silurian age; the majority of those exposed on the coast are of Wenlock or Wenlock-Llandovery age, while the majority of those exposed inland are of Ludlow age. The general classification is as follows :—

		Feet.
Lower Devonian......	Dingle Series.	
Ludlow	5. Croaghmarhin Beds: calcareous sandstones and flags of Ludlow age	? 1,000
Wenlock	4. Drom Point Beds ....about	600
	3. Red sandstones and ashes, with green ash at the top..	350
	2. Clogher Head Series: calcareous flags and slates, with abundant contemporaneous igneous rocks	550
Wenlock-Llandovery	1. Ferriter's Cove Beds: chiefly calcareous flags, with a subordinate development of contemporaneous igneous rocks	2,300
?	Smerwick Beds.	

Contemporaneous volcanic rocks are first met with low down in the Wenlock-Llandovery Series, and reach their maximum in the Wenlock Series, especially in the southern part of the area. There are ashes but no lavas in the Ludlow. The volcanic rocks are all of acid character, and include nodular, banded, and non-banded rhyolites, with tuffs and ashes both coarse and fine. The Dingle Beds appear to be conformable, but movement occurred before the Old Red Sandstone Conglomerate was laid down, and the overfolding and thrusting probably took place during the post-Carboniferous period of earth-movement. Before the last movement fine-grained diabasic rocks ('greenstones') appear to have been intruded. The thickening of the volcanic rocks to the southward seems to indicate that the vents must have been situated in this quarter. The beds as a whole were deposited in shallow water in the proximity of land, and they point to the existence of rocks, such as granites, not now known at the surface in the district.

2. "A Process for the Mineral Analysis of Rocks." By W. J. Sollas, D.Sc., LL.D., F.R.S., F.G.S., Professor of Geology in the University of Oxford.

The method proposed is to obtain a quantitative estimation of the mineral composition of a rock, and from the known composition of the minerals to calculate the percentage composition of the rock. The specific gravities of the minerals are first determined by means of a diffusion column of methylene-iodide and beads of known specific gravity, and the presence or absence of particular minerals settled for a certainty. Next, the separation of the minerals in a weighed quantity of the powdered rock is undertaken by means of a special separator; the method being illustrated by the example of a rock containing orthoclase (sp. gr. 2·56), quartz (2·65), andesine (2·67), biotite (3·1), pyroxene (3·3), and magnetite. The first separation would be with a liquid of sp. gr. 2·885, the mean of that of andesine and biotite; the next with a liquid of sp. gr. 2·66; the next 2·605, and so on for the other constituents. The separated minerals are dried and weighed, the loss distributed, and the analysis checked by comparing the specific gravity of the rock in bulk with that calculated from the specific gravity and proportion by weight of its constituents. In making choice of particular mineral analyses for calculating the chemical composition, there are three guiding principles: the analysis should be that of a mineral obtained from the same kind of rock as the one under investigation; if possible, from the same locality; and with the same specific gravity. The process was tested on specimens of kentallenite supplied by Mr. Teall and of gabbros from Skye by Mr. Harker, and in both cases the results compared closely with those obtained from bulk analysis of the same rocks. A further test was the comparison of the mineral analysis by Miss Davies of a specimen of Devonshire granite with Phillips's published analysis; also of syenite from the Plauens'cher-grund, and of tonalite from Adamello, with published analyses.

II.—February 5th, 1902.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair.

Mr. H. Bauerman, in exhibiting a remarkable Crystal of Cinnabar from the Mercury-mines in the province of Kwei-chau (China), observed that it was a completely developed penetration-twin of two rhombohedra, attached to a mass of crystalline quartz. He drew attention to the simple character of the form from this locality, as compared with those of the crystals from Almaden and Avala.

The following communications were read :—

1. "The Matrix of the Suffolk Chalky Boulder-clay." By the Rev. Edwin Hill, M.A., F.G.S.

The author has been examining with the microscope washed residues from Boulder-clays. He is able to group together the specimens from localities along a belt of country from Lowestoft to Bury St. Edmunds, as containing granules of Secondary clays and limestones. Other specimens contain granules which may be the same kind decomposed, others granules of other kinds; all these lie outside the belt occupied by the group, though some are very near it. The granules of the group, derived from Secondary rocks, may all have come from the west.

Certain peculiar round grains, found generally, except in the extreme east and north, are also probably from Secondary rocks, and they too point to a western origin.

The clays of the group, though some occupy the coast-cliffs, contain so little sand, that they cannot be supposed to have been brought from the side of the sea, that is, from the east.

All the residues have been examined for coal-dust. Though this is contained in Glacial clays along the eastern coast of England as far south as the Wash, and probably farther, it is either altogether absent from the group or present only on its eastern edge. It appears to be absent from the clays which border the group on the north.

These results combined lead to the conclusion that the materials of the matrix in the Suffolk Chalky Boulder-clay were not brought from the east or north, but from inland; and not from so far inland as the Coalfields. Their sources therefore lie on a limited belt, bordering the Boulder-clay area.

With this agrees the evidence of the included boulders as a whole.

2. "On the Relation of certain Breccias to the Physical Geography of their Age." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

The author has endeavoured in this paper to collect from published accounts and his own observations the evidence which certain well-known and important beds of breccia afford as to the physical conditions prevalent when they were formed. First come sketches of the principal breccias in the Rothliegende, the brockrams of the North-West of England and similar deposits in Armagh, the breccia-beds of the Midlands and of Devon, and those of the Thüringerwald. The fragments in these vary from angular to subangular, are sometimes interstratified with beds of finer material, sometimes are themselves slightly stratified. They form marginal fringes to old land-masses, from which we may, with more or less certainty, infer them to have been derived, and are sometimes found to extend outward from them, wedge-fashion, for a few miles. They appear, for reasons given, to have been the products of bare rocky hill-slopes, rather than of mountain torrents. Floating ice has been suggested as a means of transport, though the idea that the Clent and Enville breccias indicate the former existence of glaciers is not now generally accepted, Mr. Wickham King having shown the materials to have been derived from land-masses in the neighbourhood, and Mr. R. D. Oldham having pointed out their resemblance to certain Indian breccias.

The so-called Dolomitic Conglomerate of the South-West of England, which exhibits similar characters, though on a smaller scale, and the remarkable breccias in the Upper Oolite of Caithness described by Professor Judd, are next noticed, after which the author passes on to the breccia-beds in the Alpine Flysch, taking as examples those of the Habkerenthal and of the Val des Ormonts. The former apparently are more sporadic in character, and are suggestive of the intervention of floating ice; the latter are more regularly interbanded, and that with true marine deposits: their occurrence is extremely difficult to explain, without assuming the existence of a mountain range or a great highland district in their immediate neighbourhood.

When we seek for parallels to these breccias in deposits of late date or in process of formation, we find some resemblances to them in the breccias of Gibraltar described by Sir Andrew Ramsay and Professor James Geikie, in the stone-rivers of the Falkland Isles described by Sir Wyville Thomson, and in the breccias of Persia and other parts of Central Asia described by Dr. Blanford. The author accordingly infers the Rothliegende (and probably the Triassic) breccias to be indicative of a continental climate, due to a great extension of land or more probably the existence of a mountain region on the west—winters with severe cold and snow, but rather hot and arid summers. The Caithness breccias were perhaps more analogous to the stone-rivers of the Falkland Islands, but they also indicate a rather low temperature; while the Flysch breccias land us in the following dilemma, namely, that either similar temperatures existed in Switzerland, and that there was also an important highland district, of which no remnant can be found, within a short distance of the breccia-beds; or they must be the product of a range not inferior to the present Alps, which also has completely disappeared, and would be (for reasons given) very difficult to locate. But, even in the latter case, we seem forced to admit that a temperature, if not lower, at any rate not higher than the present, prevailed in Central Europe late in the Eocene Period.

CORRESPONDENCE.

EFFECTS OF LIGHTNING NEAR SNOWDON.

SIR,—I found last November on the hills between Cynicht and Nant y Mor two crags that had been struck by lightning. The scars on one of them were so fresh that I felt sure they had been made during a heavy thunderstorm which passed over the district on the 29th of last July, the only thunderstorm there was in this part of Wales last Summer. On asking Mr. Roberts of Gelli Iago, who farms the land, I was told that such was the case, and that the other crag had been struck during the very heavy thunderstorm which passed over the district on a Sunday evening in the Summer of 1898 (I do not remember the exact date), when several beasts were killed by lightning. In this case some blocks have been thrown eighteen yards from the parent rock; the largest of these is between ten and eleven cubic feet in size, and there are several others lying beside it measuring three cubic feet and less. One huge block measuring sixty-four cubic feet had been thrown twenty-six yards. There are no marks of vitrifaction on the stricken crags nor on the detached fragments. The lightning has done nothing more than to break off slices and chunks and cast them to a distance.

On subsequently examining the ground again I found several other places where the rocks had been struck by lightning.

The name of the place given on the Ordnance Map is Cerig y Mellt. If this name is correct it is significant, for the words mean 'rocks of lightning'; but there is some doubt as to what is the correct name, for Mr. Roberts tells me that he learnt from his father to call the place Cerig y Myllt, which means 'rocks of the wethers.'

J. R. Dakyns.

Snowdon View, Nant Gwynant, Beddgelert.
January 25, 1902.

OBITUARY.

HON. CLARENCE KING, F.G.S.

Born . Died December 24, 1901.

In the death of Clarence King geological science has lost one who rendered distinguished service in the surveys of the United States. He was born at Newport, Rhode Island, and graduated from the Sheffield Scientific School of Yale University in 1852. He prepared the geological and topographical atlas and several important reports for the Geological Exploration of the Fortieth Parallel, and when in 1880 this and other geological surveys were amalgamated as the United States Geological Survey, Mr. King was appointed Director. Under his charge the Survey was carried on with vigour, and special investigations were made on regions of exceptional economic importance. A year later, however, Mr. King relinquished his position, desiring to devote himself unfettered to geological research. His fame, however, rests on his official work. Mr. King died at Phœnix, Arizona, on December 24th, 1901.

REV. FREDERICK SMITHE, M.A., LL.D., F.G.S.

Born 1822. Died December 9, 1900.

We learn from the recently published Address of the President of the Cotteswold Club (Mr. E. B. Wethered) of the death more than a year ago of Dr. Frederick Smithe, vicar of Churchdown in Gloucestershire. He laboured for many years with great enthusiasm at the fossils of the Middle and Upper Lias in the outliers of Churchdown, Alderton and Dumbleton; and his observations on these and other subjects were communicated to the Proceedings of the Cotteswold Club. He belonged to an Irish family, and was educated at Trinity College, Dublin.

MISCELLANEOUS.

Royal Society.—A revised and much enlarged edition of the Record of the Royal Society of London has lately been issued. The principal feature of the new edition is the inclusion of two lists of Fellows of the Society from its foundation to the end of 1900, one arranged chronologically and the other alphabetically. It would have been interesting to have portraits of the thirty-seven presidents, but none of those given in the former edition of the Record published in 1897 are repeated, while three only are now inserted. Geological science has been represented in the presidential chair by Wollaston, the Marquis of Northampton, and Huxley.

Geological Survey.—Mr. R. H. Tiddeman, M.A., F.G.S., who joined the staff of the Geological Survey in 1864, under Murchison, has just retired from the public service.

American Museum of Natural History.—In vol. xi of the Bulletin of this Museum there has been published a catalogue of the types and figured fossils contained in the geological department, and which number 8,345, representing 2,721 species and 190 varieties. The catalogue has been prepared by Mr. R. P. Whitfield, the Curator, and his associate Mr. E. O. Hovey. The chief palæontological possession of the Museum is the great James Hall collection, which was purchased in 1875, and which includes a large number of type and other illustrated specimens, especially of Palæozoic species. Most of the 'figured specimens' in the series are those which were identified, redescribed, illustrated, and published by Professor Hall in the early volumes of the "Palæontology of New York." The Museum also has the Holmes collection, which includes more than two hundred of the specimens described and figured in Tuomey and Holmes's "Pliocene Fossils of South Carolina" and in Francis S. Holmes's work on the "Post-Pliocene Fossils of South Carolina." It contains, moreover, many Cretaceous forms from Beirût, Syria, and from Jamaica. The term 'type' is employed to embrace not only the specimens actually used by an author in the original description of a species, but also those specimens which have been used by the same author in the further elucidation of the species in subsequent publications. 'Figured specimen' is the term applied here to the specimens which have been identified with a species by another person than the author of the species, and which have been illustrated in some publication.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. IX.

No. IV.—APRIL, 1902.

ORIGINAL ARTICLES.

I.—Woodwardian Museum Notes: Salter's Undescribed Species. VII.[1]

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

(PLATE VII.)

CEPHALOPODA.

Trochoceras spurium, Salter, 1873. (Pl. VII, Fig. 1.)

1873. *Trochoceras spurium*, Salter, n.sp.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 160 (*a* 466).
1882. *Trochoceras striatum*, Blake: Brit. Foss. Ceph., p. 222, pl. xxix, fig. 5; pl. xxx, figs. 3, 4, 4*a*, 4*b*.
1891. *Trochoceras striatum*, Foord: Cat. Foss. Ceph. Brit. Mus., p. 32.
1891. *Trochoceras spurium*, Woods: Cat. Type Foss. Woodw. Mus., p. 131.

Salter's original specimen comes from the Wenlock Shale, Builth Bridge, and was described (Salter, loc. cit.) as having "much narrower whorls than *Phr. nautileum.*" The specimen consists only of the greater portion of the outer whorl, including the body-chamber, and it shows the aperture and ornamentation very well preserved. It agrees with Blake's species *Tr. striatum* in shape, rate of increase, characters of body-chamber and aperture, degree of obliquity of the transverse ribs, their absence on the body-chamber, the fine lines parallel to them on the rest of the whorl, the epidermids, and the shape, position, and distance apart of the septa. The stratigraphical horizon on which it is found is also the same, and there can be no doubt that the species are identical, as they agree in all the essential characters and even in every minute detail.

Orthoceras fluctuatum, Salter. (Pl. VII, Fig. 2.)

1873. *Orthoceras fluctuatum*, Salter, n.sp.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 37 (*a* 611).
1882. *Orthoceras fluctuatum*, Blake: Brit. Foss. Ceph., p. 122 (cf. *O. recticinctum*, Blake).
1891. *Orthoceras fluctuatum*, Woods: Cat. Type Foss. Woodw. Mus., p. 129.

Salter describes this species as possessing "coarser striæ than *O. subundulatum*, Portl., and apparently more bent still than in that species." The single specimen (*a* 611) named by Salter comes from the Lower Bala (Llandeilo) of Wellfield, Builth, and consists of an imperfect external hollow cast of a portion of the shell, showing

[1] For previous articles see Geol. Mag., 1901, pp. 5, 106, 246, 355, and 576; 1902, p. 122.

a series of undulating, equidistant, regular, transverse, coarse striæ, six in a space of 4 mm. These striæ on the cast would be represented on the surface of the shell by raised thread-like lines. But this material is absolutely insufficient for the creation of a new species, and Blake (loc. cit.) hesitates in identifying it with *O. recticinctum*, partly on the ground of its imperfect preservation and partly because it comes from a different geological horizon. It seems advisable, therefore, to let the name drop, as the original specimen does not admit of a sound species being established.

LAMELLIBRANCHIATA.

Pterinea exasperata, Salter. (Pl. VII, Figs. 3–5.)

1873. *Pterinea exasperata*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 150 (*a* 813, *a* 814, *a* 815, *a* 816).
1891. *Pterinæa exasperata*, Woods: Cat. Type Foss. Woodw. Mus., p. 89.

The specimens labelled *Pterinea exasperata* by Salter are eleven in number. All are from the Wenlock Limestone of Dudley and belong to the Fletcher Collection. One has both valves preserved, though the right one is somewhat imperfect. The others are all left valves, and one (*a* 815) shows the inner side of this valve. Five more specimens of this species have been acquired since 1873. Salter (loc. cit.) described it as "a reticulate species, long known but not yet described."

Diagnosis.—Body of shell obliquely ovate, elongate, unequally biconvex; long straight hinge-line; left valve slightly more convex than the right; furnished with small rounded, triangular anterior ear and large flattened posterior wing.

Left valve with obliquely elongate convex body; beak gibbous, prominent; anterior ear not sharply marked off from body; posterior wing large, pointed, more than two-thirds the length of posterior slope, depressed, flattened, more or less distinctly marked off from body, posterior margin concave. Hinge-line long, straight, making angle of about 30°–40° with body behind umbo.

Surface of body marked by strong, straight, radiating, narrow, equidistant ribs, 25 to 35 in number, very feebly developed or absent on anterior and posterior ears. Half-way between each pair of these main ribs is a finer, thread-like rib which begins at some distance from the beak, and increases in strength towards the margin so as ultimately to be equal in size to the main ribs. Ribs crossed by regular, equidistant, concentric, scale-like lamellæ, arched backwards towards the umbo between each pair of main ribs, and between every pair of ribs near the ventral margin. The lamellæ are continued on to the ears, where they are more closely packed together and crenulated, and on the posterior ear are parallel to the concave posterior margin. Right valve rather less convex than left valve, but in other respects apparently similar.

Measurements.

	I.	II.	III.
	mm.	mm.	mm.
Length along oblique axis of body	30	30	43
Length at posterior end	21	23	31
Width along hinge-line	24	22	28

Remarks.—A species which appears to be closely allied to this form is *Pt. fimbriata*[1] (McCoy), from the Silurian (Wenlock?) of Dingle, co. Kerry. This Irish species differs, however, in being less elongated, in possessing a shorter posterior wing and a more acute umbo, but the ornamentation of the surface closely agrees. McCoy figures only a right valve. From *Pt. subfalcata* (Conr.) our species differs in the regularity and strength of its concentric lamellation, in its larger posterior ear, and the different shape of its anterior ear.

Pterinea condor, Salter. (Pl. VII, Figs. 6 and 7.)

1873. *Pterinea condor*, Salter, n.sp.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 169 (*a* 809, *a* 810).
1891. *Pterinæa condor*, Woods: Cat. Type Foss. Woodw. Mus., p. 89.

There are three specimens labelled *Pterinea condor* by Salter, but one of these (*a* 810) is probably due to a mistake, as it obviously belongs to an entirely different species. The specimens all come from the Lower Ludlow beds of Dudley and belong to the Fletcher Collection. Salter describes it as having "very wide hinge line, three inches broad."

Diagnosis.—Shell transversely oblong, very inequivalve, flattened. Hinge-line long, straight. Left valve weakly convex, flattened posteriorly into large posterior wing, which is bluntly pointed behind, slightly excavated along posterior margin, and extended along upper margin beyond body of shell. Hinge-line longer than shell. Anterior ear very small, depressed below body of valve. Umbo small, prominent, rising above hinge-line. Distinct band along hinge-line marked off from posterior wing, representing ligamental facet. Surface of valve marked by faint concentric striæ parallel to margins.

Right valve (? of same species), Fig. 7, subquadrate, flattened. Upper and anterior margins straight, meeting at angle of 120°, each furnished with longitudinally striated, band-like area, of which the upper is marked with five longitudinal shallow grooves, interrupted along part of their length near anterior end. Posterior margin broadly rounded, weakly emarginate at inferior angle. Inferior margin rounded, meeting anterior margin at nearly a right angle. General surface of valve feebly convex, especially in central part of hinge-line. Oval muscular impression in anterior angle between upper and anterior margins.

Measurements.

	mm.
Left valve.	
Width (along hinge-line)	74
Length	40
Right valve.	
Width (along hinge-line)	31
Length	32

Remarks.—This form most resembles *Pterinea retroflexa*, var. *naviformis* (Conr.), but differs in its more extended hinge-line and more pointed posterior wing, as far as the left valve is concerned.

[1] McCoy: Silur. Foss. Irel., 1846, p. 21, pl. ii, fig. 7; Brit. Pal. Foss., 1851, p. 263, pl. ii, figs. 3, 3*a*.

The great inequality and difference of shape of the opposite valves ascribed to the same species are also characteristic and peculiar features.

EXPLANATION OF PLATE VII.

FIG. 1.—*Trochoceras spurium*, Salter (*a* 466). Wenlock Shale: Builth Bridge. Drawn nat. size.
FIG. 2.—*Orthoceras fluctuatum*, Salter (*a* 611). Lower Bala (Llandeilo): Wellfield, Builth. × twice nat. size.
FIG. 3.—*Pterinea exasperata*, Salter (*a* 816). Wenlock Limestone: Dudley. × 1½ nat. size.
FIG. 4.—Ditto (*a* 813).
FIG. 5.—Ditto (*a* 816), 4 ribs enlarged 4 times nat. size, to show ornamentation.
FIG. 6.—*Pterinea condor*, Salter (*a* 809). Lower Ludlow Beds: Dudley. Left valve. Nat. size.
FIG. 7.—Ditto, right valve (*a* 810), nat. size.

II.—ON *CAMPYLOPRION*, A NEW FORM OF *EDESTUS*-LIKE DENTITION.

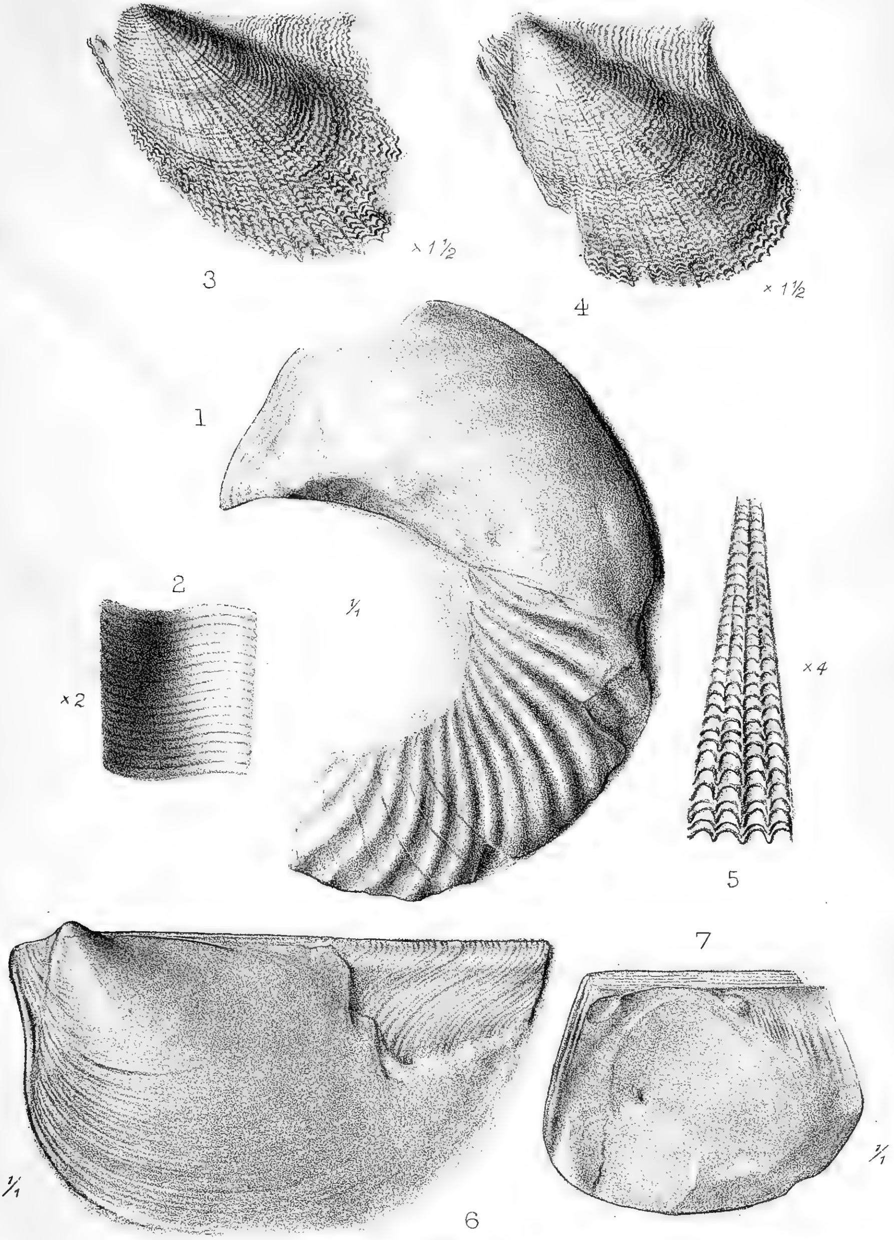
By Dr. C. R. EASTMAN, of Cambridge, Mass., U.S.A.

(PLATE VIII.)

IN the January number of the GEOLOGICAL MAGAZINE for 1886, an elaborate description is given by Dr. Henry Woodward of a peculiar ichthyic structure from the Carboniferous of Western Australia, which is referred by him provisionally to *Edestus*, under the specific title of *E. davisii*. Interesting comparisons are drawn between this and other known species of *Edestus*, and the hypothesis advanced that it is a pectoral fin-spine, resembling in its segmented character the Cretaceous *Pelecopterus*. This segmentation, which is so conspicuous a feature of *Edestus*, is attributed by Dr. Bashford Dean in his book on "Fishes, Living and Fossil," to a metameral origin, and he follows Leidy, Owen, Cope, Newberry, and others in interpreting all this class of remains as dorsal fin-spines.

As early as 1855 Louis Agassiz [1] compared the type-specimen of *Edestus minor*, Newberry, with the rostral prolongation of *Pristis*, and pronounced it a dermal defence, pertaining probably to the snout region of a shark or skate. Quite recently this hypothesis has been revived by Dr. A. Karpinsky, Director of the Russian Geological Survey, in his superb memoir on *Helicoprion*,[2] a spirally coiled form whose segments resemble those of *Edestus*, and is regarded by the author as a powerful weapon placed above the snout in the median line. To this Permo-Carboniferous genus, *Helicoprion*, the Russian Director also refers the Australian form described by Dr. Henry Woodward as *Edestus davisii*, which differs principally in the lesser extent of its spiral. In an appreciative review of his monograph, Dr. Arthur Smith Woodward [3] questions the probability of Karpinsky's conjecture, and cites a recent discovery made by Dr. Traquair in the Lower Devonian of Forfarshire, which "proves

[1] Proc. Amer. Assoc. Adv. Sci., 1855 (1856), p. 229.
[2] Verh. k. russ. min. Ges. St. Petersburg, 1899, ser. II, vol. xxxvi, No. 2.
[3] GEOL. MAG., 1900, Dec. IV, Vol. VII, p. 33.



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

Ordovician and Silurian Mollusca.

FIG. 1.

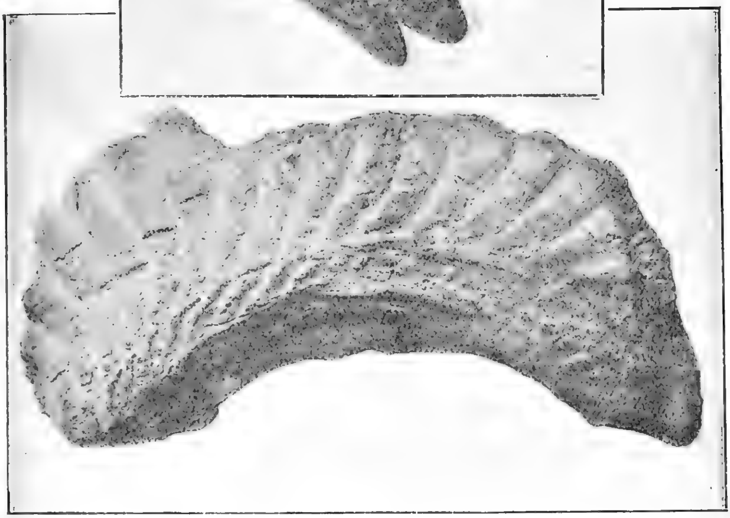


FIG. 2.

Symphysial Teeth of Palæozoic Sharks.

FIG. 1.—*Campodus variabilis* (Newb. & W.): Coal-measures, Cedar Creek, Nebraska.
FIG. 2.—*Campyloprion annectans*, C. R. Eastman, gen. et sp. nov. (loc. unknown).
(About one-third natural size.)

undoubtedly that there were Palæozoic sharks with sharp, piercing teeth, which were never shed, but became fused into whorls as the animal grew."

The same memoir was also reviewed by the present writer,[1] who brought forward additional instances of coiling amongst Palæozoic sharks, and was inclined to look upon the segments of *Helicoprion* as veritable teeth. Finally, a fortunate discovery of the symphysial dentition of the Carboniferous genus *Campodus*, made by Professor E. H. Barbour, Director of the Nebraska University Geological Survey, threw new light on the matter, and furnished ground for a positive statement that the fused segments of *Edestus* and *Helicoprion* are actually teeth belonging to the anterior series of Cestraciont sharks. The evidence for this was presented by the writer before the Denver meeting of the American Association for the Advancement of Science, and in the published abstract of that paper[2] the arrangement of the anterior series in *Campodus variabilis* (Newb. & W.) was briefly described. A second specimen in the Museum of Comparative Zoology at Cambridge, Mass., from the Coal-measures of Osage County, Kansas, exhibits the symphysial series in natural association with the lateral. Professor Barbour's specimen, shown in the accompanying Plate VIII, Fig. 1, is more perfect in some respects, but has none of the lateral series associated with it.

Each individual of *Campodus* is known to have possessed at least three series of coalesced anterior or symphysial teeth. As indicated by the marks of contact, there was a median arched azygous series in one jaw (presumably the lower, as is the case in *Cestracion, Chlamydoselache,* and other existing sharks), opposed to which in (presumably) the upper jaw were two corresponding series separated from each other by a slight interval. The orientation of both the symphysial and lateral teeth of *Campodus* may be determined from the fact that their coronal buttresses are directed outward, instead of inward, as was erroneously supposed by Messrs. St. John and Worthen. Several series of anterior teeth, all coiled in a single plane, are known to have been present in the same mouth of *Campodus, Protodus, Periplectrodus,* and certain Cochliodonts, hence it is probable that a like condition was true of *Edestus* and *Helicoprion.* In the two last-named genera it was rightly pointed out by Smith Woodward that the absence of lateral facettes or marks of contact with adjoining whorls indicates that the series were separated from one another, as in the existing *Chlamydoselache.* In the light of the now clearly apparent odontological nature of *Edestus* and *Helicoprion,* together with their Cestraciont affinities, it may be pertinent to inquire whether the huge fin-spines from the Carboniferous, such as *Oracanthus, Phoderacanthus, Stichacanthus,* and the like, were not borne by creatures having an *Edestus*- or *Campodus*-like dentition.

[1] Amer. Nat., 1900, vol. xxxiv, p. 579.
[2] Science, N.S., 1901, vol. xiv, p. 795.

DESCRIPTION OF *CAMPYLOPRION ANNECTANS*, gen. et sp. nov. (Pl. VIII, Fig. 2; and Woodcut, Fig. 3, in text.)

In the same category with *Edestus* and *Helicoprion* must be placed a new genus of Palæozoic Cestracionts, known as yet only by its symphysial dentition, for which the name *Campyloprion* is proposed, with the type species of *C. annectans*. This is founded on a unique specimen belonging to Tufts College Museum, Boston, the description of which follows. The new genus is also held to include two species originally assigned to *Edestus*, namely, *E. davisii*, Woodward, and *E. lecontei*, Dean. The former of these has been discussed in its relations to other *Edestus*-like structures by Woodward, Dean, and Karpinsky, and was transferred by the last-named author to *Helicoprion*. For the sake of comparison we may briefly summarize the distinguishing characters of these four closely related genera, as follows:—

1. *Campodus*.—Anterior series of thirteen or more teeth fused into a semicircular arch, their outer (anterior) coronal margins prominently buttressed, and their coronal apices rather obtuse and not serrated; the teeth only slightly overriding one another at their extremities, not much laterally compressed, and very much larger than the immediately adjoining lateral series, which also have their buttresses directed outward. Type, *C. agassizianus*, Koninck.

2. *Edestus*.—Anterior series of seven or more fused teeth only moderately arched and laterally compressed; coronal apices acuminate and serrated along the sharpened anterior and posterior margins; bases strongly reflected forward, invaginated, and fused throughout. Lateral series unknown. Type, *E. vorax*, Leidy.

3. *Campyloprion*.—Anterior series of twenty or more fused teeth considerably arched and much laterally compressed; coronal apices rather obtuse, and coarsely serrated along the sharpened anterior and posterior margins; teeth curved or bent forward, overriding one another toward their extremities and fused for the greater portion of their length. Type, *C. annectans*, sp. nov.

4. *Helicoprion*.—Anterior series consisting of upwards of 150 fused teeth, very similar to the last in form, but coiled into approximately 3½ whorls; coronal apices acute and finely serrated along the sharpened anterior and posterior margins; enamel extending far down the lateral faces; teeth more or less strongly curved forward, overlapping and fused for a portion of their length; two lateral grooves extending along the spiral near the bottom. Lateral series unknown. Type, *H. bessonowi*, Karpinsky.

Arranged in the above order we are enabled to note the progressive stages by which the typical Cestraciont dentition of *Orodus* and *Campodus*, occurring in the Carboniferous, passed into the excessively modified spirals of *Helicoprion* in the Permian. Moreover, the chief interest attaching to *Campyloprion* is on account of its intermediate position, two of its species linking it with *Edestus*, as already observed, and a third, as denoted by its trivial title, marking the transition to *Helicoprion*.

For the opportunity to describe the interesting series of teeth shown in Plate VIII, Fig. 2, and section in text, Fig. 3, the writer is indebted to his friend Dr. J. S. Kingsley, of Tufts College, in whose custody it has been for many years. Unfortunately nothing is known of the history of the specimen prior to its coming to Tufts, except that it was procured for the Museum by the late Professor Marshall. While its age may be confidently attributed to the Upper Carboniferous or Permian, there is no clue as to its locality. The specimen is arcuate in form, with an extreme length of about 24 cm., and comprising twenty fused teeth, only four of which, however, are perfectly preserved. A transverse section of the specimen taken vertically from the apex of the largest tooth, where the height is about 8 cm., is shown in Fig. 3. All the teeth have suffered greatly from the effects of weathering, which has removed most of the enamel, and from post-mortem abrasion. In general form they resemble those of *Helicoprion bessonowi*, but are less angularly bent, in which respect they differ also from *C. davisii*; in addition, their apices are more obtuse and more coarsely serrated. Both of these species of *Campyloprion* differ from the Russian form in their lesser degree of curvature, and it is extremely improbable that either of them was coiled into a complete spiral. Neither do they exhibit the double lateral grooves which traverse the spirals of *Helicoprion*. It is possible that the indistinct patches of enamel observed along the base of the present specimen may represent an adjacent series of small teeth, such as occur in juxtaposition to the symphysial series of *Campodus variabilis*. A more detailed account of the dentition of the latter form will be given in a forthcoming number of the Bulletin of the Museum of Comparative Zoology.

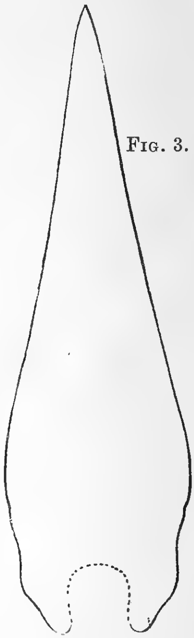


FIG. 3.

Vertical section of Fig. 2.
Campyloprion annectans.

EXPLANATION OF FIGURES.

PL. VIII, FIG. 1.—*Campodus variabilis* (Newb. & W.). Coal-measures: Cedar Creek, Nebraska. Symphysial series of teeth belonging (presumably) to the lower jaw, viewed from the right-hand side. Original preserved in the Museum of Nebraska State University at Lincoln. Reduced to about one-half nat. size.

PL. VIII, FIG. 2.—*Campyloprion annectans*, gen. et sp. nov. Carboniferous or Permian: locality unknown. Left lateral aspect of a portion of the anterior dentition, showing portions of 20 coalesced teeth, supported at their bases by a band of calcified cartilage. Reduced.

FIG. 3 (in text).—*Campyloprion annectans*. Vertical cross-section of specimen shown in Fig. 2, passing through apex of largest tooth in the series. Reduced to about one-third nat. size.

III.—THE VENTRAL INTEGUMENT OF TRILOBITES.[1]

By Professor CHARLES E. BEECHER, Ph.D., For. Corr. Geol. Soc. Lond., Yale University, New Haven, Conn., U.S.A.

(PLATES IX–XI.)

IN previous papers by the writer on the structure and appendages of *Triarthrus*,[2] no attempt has been made to describe or illustrate the character of the ventral integument, especially in the sternal or

[1] Reprinted by permission from the Amer. Journ. Sci. [4], vol. xiii (1902), pp. 165–174.

[2] C. E. Beecher, "On the Thoracic Legs of Trilobites": Amer. Journ. Sci. [3],

axial region. The specimens hitherto described were prepared to show details of the appendages, and though portions of the ventral membrane were exposed in many individuals, the subject was not considered of sufficient moment to warrant a distinct study, particularly as no characters were observed in the cuticle that had not been previously seen in more or less perfection by Walcott[1] in the genera *Ceraurus* and *Calymene.* A recent discovery by Jaekel,[2] however, necessitates the separate consideration of this structure. This necessity arises from the fact that a positive addition to the knowledge of the trilobite anatomy may be deduced, although, as will be shown, Jaekel was apparently entirely misled in his interpretation of the nature of his discovery.

In the paper under discussion, Jaekel[2] states that the occasion for his publication arose from the finding of a specimen of ***Ptychoparia striata***, from the Cambrian of Bohemia, in which some structures were preserved in the axis of the six anterior segments of the thorax. These, he asserts, are the proximal joints of the legs.

The specimen was preserved as a cast in a rather coarse-grained sandstone, and is exposed from the dorsal side. From certain surface indications of lines in the cast, Jaekel was led to follow these into the rock filling the axis, and succeeded in finding a central groove, with two oblique grooves on each side. These he considered as representing the cavities left by the removal of the test from the basal joints of the legs, which thus must have been attached along the median line of the sternum. The supposed joints of the legs were filled with rock, and his attempts to separate them from the matrix resulted in failure.

In the oral region, there were still more indefinite and obscure evidences of cavities left by the removal of some ventral testaceous structure.

These meagre remains in the rachis of the thoracic and oral regions have furnished data for what must be considered as the most remarkable and erroneous reconstruction of the trilobite appendages and anatomy that has appeared since the time of Burmeister,[3] in 1843. The latter, in the absence of any material, confessedly based his opinions of the ventral anatomy wholly upon theoretical considerations. Not only has Jaekel to a large degree set aside the evidence presented by many scores of specimens of *Triarthrus*, as described by the writer, in which each detail of

vol. xlvi (1893). "On the Mode of Occurrence, and the Structure and Development of *Triarthrus Becki*": Amer. Geol., vol. xiii (1894). "The Appendages of the Pygidium of *Triarthrus*": Amer. Journ. Sci. [3], vol. xlvii (1894). "Further Observations on the Ventral Structure of *Triarthrus*": Amer. Geol., vol. xv (1895). "The Morphology of *Triarthrus*": Amer. Journ. Sci. [4], vol. i (1896); GEOL. MAG., Dec. IV, Vol. III (1896).

[1] C. D. Walcott, "The Trilobite: New and Old Evidence relating to its Organization": Bull. Mus. Comp. Zool., vol. viii, No. 10 (1881). "Appendages of the Trilobite": Science, vol. iii, No. 57 (1884).

[2] Otto Jaekel, "Beiträge zur Beurtheilung der Trilobiten," Theil i: Zeitschr. Deutsch. Geol. Gesell., Bd. liii, Heft 1 (1901).

[3] Hermann Burmeister: "Die Organisation der Trilobiten," etc., 1843.

structure can be verified indefinitely, but has also overlooked that afforded by the material illustrated by Walcott,[1] Billings,[2] Mickleborough,[3] and Woodward.[4] Moreover, this single specimen of *Ptychoparia* has led its describer to reconsider on a false premise the entire question of the anatomy, ontogeny, phylogeny, and affinities of the trilobite.

It is the purpose of the present article to show that numerous individuals of *Triarthrus*, as well as some material representing other genera, preserve evidence of what seem to be the same structures as those described by Jaekel in *Ptychoparia*, and also present indisputable testimony as to their correct nature. It will be demonstrated that they do not belong in any way to the appendicular system of the trilobites, but are really the buttresses and apodemes of the ventral body integument.

The marvellous state of preservation of many of the specimens of *Triarthrus*, whose appendages have been studied by the writer, affords very satisfactory indications, not only of the presence of a ventral integument, but also of some of its detailed characters. Jaekel states that in his opinion the *unfavourable* ("*ungünstigen*") preservation of *Triarthrus* has obscured the proximal structure of the legs, so that what he calls the three basal joints are equivalent to the single unjointed gnathobase of the coxopodite, as described by the writer. Inasmuch as Jaekel has never seen the original specimens described, his statement is practically without foundation. It may also be added that the types and best-preserved individuals have been retained in the collections of the Yale University Museum. The photographic illustrations accompanying this article, it is believed, will refute his statement, and the specimens themselves would serve the same purpose more completely, since from the black nature of the rock and the nonactinic character of the fossils the photographs feebly represent the delicate structures actually preserved, which are clearly visible to the eye.

The ventral membrane of *Triarthrus*, as well as of other trilobites where it has been observed, is of extreme tenuity, and only under the most favourable conditions has it been preserved. The membrane itself was a thin, uncalcified, chitinous, flexible pellicle, and thus was in strong contrast with the much thicker and calcified dorsal test.

In the preparation of a specimen to show the appendages from the ventral side, very little of the ventral membrane is commonly exposed, owing to the crowded arrangement of the legs, but when the appendages are removed it is possible to view the entire ventral integument. This process has been carried out in a considerable

[1] Op. cit.

[2] E. Billings, "Notes on some Specimens of Lower Silurian Trilobites": Quart. Journ. Geol. Soc., vol. xxvi (1870).

[3] J. Mickleborough, "Locomotory Appendages of Trilobites": Journ. Cinti. Soc. Nat. Hist., vol. vi, No. 3 (1883).

[4] Henry Woodward, "Note on the Palpus and other Appendages of *Asaphus*, from the Trenton Limestone, in the British Museum": Quart. Journ. Geol. Soc., vol. xxvi (1870).

number of specimens, and some of the more evident characters are herewith described.

The membrane under each pleuron (pleurotergite, Jaekel), or the pleurosternite, as it may be termed,[1] was smooth and extremely thin, and in the fossils it is invariably concave. This was probably

Fig. 1.—A specimen of *Triarthrus Becki*, Green; viewed from the ventral side. The appendages have been removed and the ventral membrane exposed. In the glabellar region are seen the hypostoma, and just below it the semicircular convex metastoma with side lappets. Below, in the axial region, the buttresses and thickenings of the sternal arches are clearly marked, as described in the text. Enlarged about nine diameters.

the condition during life, to allow space for the biramous legs and for their infolding during enrolment. It should be noted, however, that the dorsal and ventral integuments in the fossils are generally very close together throughout, leaving but a small cavity for the

[1] Jaekel has suggested the name mesotergite to supplant the terms axis or tergum, and pleurotergite in place of pleuron or epimerum, as applied to the trilobites. This seems a useful terminology since the older terms are often loosely used and have somewhat different meanings in other groups. Applying this system of nomenclature to the ventral integument, the writer would propose the terms *mesosternite* for the membrane beneath each mesotergite, and *pleurosternite* for the membrane beneath each pleurotergite. The interarticular membranes are not included.

soft parts of the animal. The space inside has doubtless been considerably reduced by partial collapse from the decay of the soft parts of the animal, and also by the pressure of the sediments. The size of the body-cavity is unquestionably more correctly shown in the specimens described by Walcott[1] and Mickleborough,[2] from the Trenton limestone and Cincinnati shales respectively, where they have apparently suffered less compression.

Walcott showed that the membrane in *Calymene* and *Ceraurus* was strengthened in each segment by a transverse arch, to which the appendages were attached at the sides of the axis. These arches were connected by a thinner membrane (the interarticular membrane), and were aptly compared to the arches in the ventral integument of many of the decapods. Similar features are present in *Triarthrus*, as illustrated in Pl. XI, Fig. 1, and Figs. 1–3 in text, where it is seen that the interarticular membrane (Fig. 3) in a normally

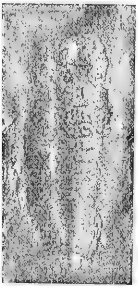


Fig. 2.—The same specimen enlarged only a little more than three diameters. The illumination is from the side opposite to that in the preceding figure.

extended individual is somewhat less than half the length of the arches. The chitinous integument of the arches, or mesosternites as they may conveniently be called, is thickened along the borders, and appears to be slightly incurved on the posterior edge. The arches are further strengthened by a series of median and oblique longitudinal ridges, or buttresses, which are generally progressively more developed in passing anteriorly from the pygidium along the thorax to the neck-segment of the cephalon.

The ventral arch of each segment has the following arrangement of these ridges :—There is first a median ridge generally extending from the posterior border entirely across the plate, but sometimes becoming obsolescent near the anterior border. Then, on each side, there is an oblique ridge making an angle of about sixty degrees with the posterior edge and extending inward, but not meeting the median ridge, thus enclosing a subtriangular space with the anterior apex truncated. Outside of these ridges, but still within the axial region, there is often a second pair of somewhat more oblique ridges, enclosing rhombic areas.

[1] Op. cit. [2] Op. cit.

The ridges are clearly produced by a thickening of the ventral integument, and can be seen when viewed from the dorsal side of a specimen in which the dorsal test and filling of the body-cavity have been removed. *They are thus partly or wholly of the nature of apodemes, or plates of chitin, which pass inward from the mesosternites and divide as well as support internal organs, and they are not, therefore, in any sense the proximal joints of legs.* Besides serving in this manner they were doubtless efficient in giving the necessary firmness to the ventral arches for the attachment of muscles.

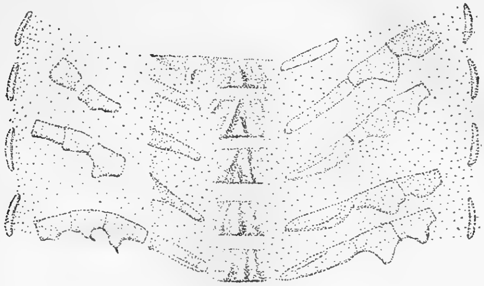


Fig. 3.—*Triarthrus Becki*, Green. The ventral side of the middle thoracic region of the specimen illustrated on Plate XI; showing the ends of the pleurotergites on the outside, with the joints of the endopodites within the pleural regions, and the gnathobases extending obliquely inward in the axis. The sternal arches with their longitudinal ridges and the interarticular membranes are represented. Enlarged four and one-fourth diameters. The extensions of the limbs beyond the carapace are omitted.

Were these observations confined wholly to the specimens of *Triarthrus*, there might still be some chance of error, although it is believed that the evidence presented by this genus alone is quite sufficient. Additional data, however, will now be given, regarding other genera and families of trilobites, described independently by other authors, and with no intention of representing the detailed characters of the ventral arches. In the search for trilobite appendages by various investigators, the ventral membrane has naturally been of secondary consideration, and in the case of Jaekel's work was of no consideration whatever.

The earliest studies and illustrations of trilobites giving some evidence of the nature of the ventral membrane are those by Walcott on the genera *Calymene* and *Ceraurus*. The limitations of the ventral body-walls of the animal were clearly shown by a marked change in the colour of the rock between the white calcite filling the body-cavity and the dark limestone matrix. In Fig. 4, after Walcott,[1] showing a transverse section of *Calymene* in the thoracic region, it is seen that the membrane in the axis, or the mesosternite, is marked by four distinct lobes representing cross sections of longitudinal folds, and also that the legs are clearly attached at the sides. These folds can in no way be construed as proximal joints of legs. The gnathobases in *Calymene* are given

[1] Op. cit.

in sections, in fig. 3, pl. iii of Walcott's paper, and of *Ceraurus,* in fig. 2 of the same plate. During a recent visit to the Museum of Comparative Zoology, the writer examined many of the sections made by Walcott during his long and successful search for trilobite appendages. The structure shown in the figure here given (Fig. 4)

FIG. 4.—Transverse section through the thoracic region of *Calymene senaria,* Conrad; after Walcott; to show the folds of the ventral integument and the basal joints of the legs, with their points of attachment at the sides of the sternal arch. Enlarged three diameters.

was verified, and other sections were observed in which the folds were more pronounced, sometimes extending as thin laminæ into the body-cavity, thus having the character of a normal apodeme.

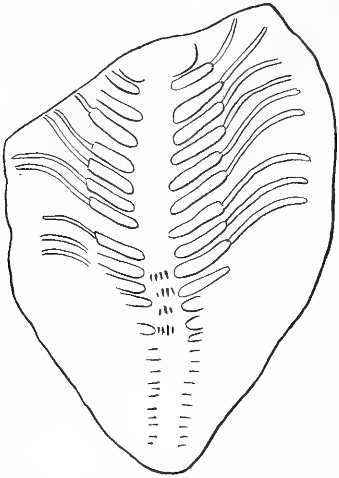


FIG. 5.—*Asaphus megistos,* Locke. A reduced outline of the figure published by Mickleborough; showing the endopodites in the pleural areas, with the gnathobases extending obliquely inward from the sides of the axis, and in the posterior thoracic median line the ridges or folds of the ventral integument. One-half natural size.

The second instance to be noted, where the ventral membrane has previously been illustrated, is a specimen of *Asaphus megistos,* Locke, first described by Mickleborough [1] from the Cincinnati shales in Ohio. In his figure, an outline of which is here reproduced (Fig. 5), there are shown a number of discontinuous longitudinal lines in the axis of the posterior thoracic region. Mr. Charles

[1] Op. cit.

Schuchert has kindly examined the original specimen, now preserved in the United States National Museum, and writes that the longitudinal wrinkles in the axis are organic and not due to accident nor to tool-marks. In the best-preserved series "there are five longitudinal ridges, a central one with two on each side." They appear in cross section, as shown in the sketch furnished by Mr. Schuchert (Fig. 6).

Fig. 6.—An enlarged profile of the mesosternal ridges of the preceding; from a sketch furnished the writer by Schuchert. The lower represents the ventral aspect.

The correct interpretation of this specimen, as illustrated by Mickleborough[1] and Walcott,[2] is: That the club-shaped bodies lying within the axis are the gnathobases attached at the sides of the axis; the curved members extending outward from the gnathobases are the endopodites; the longitudinal ridges in the ventral membrane between the inner ends of the gnathobases are the buttresses and apodemes of the mesosternites; the slender oblique rod-like bodies shown in the right pleural region in Walcott's figure are portions of the fringes of the exopodites.

The last specimen to be noted in this connection is the individual of *Ptychoparia striata*, already mentioned as described by Jaekel.[3] A reduced photographic reproduction of his figure (Fig. 7) is presented here for comparison with similar structures, as described in *Triarthrus*, *Calymene*, *Ceraurus*, and *Asaphus*. From the data here deduced, it would seem obvious that the specimen shows the imprint of the ventral integument in the axial region, the dorsal test and filling of the body-cavity having been removed. As in *Triarthrus*, the body has suffered collapse, thus bringing the dorsal and ventral walls quite near together. In the middle of each of the five or six anterior ventral arches is a groove left by the solution of the chitinous median apodeme, or buttress. On either side are two oblique grooves limiting two subangular areas, and outside of these are two other oblique grooves marking off sub-rhombic areas. The grooves in each case represent the cavities left by the removal of the chitinous thickenings of the membrane of the trilobite. Jaekel's attempt to remove the rock filling these areas naturally was ineffectual, since the latter represent the actual impression of the ventral integument. Were they simply the fillings of the hollow leg joints, as he claims, they should be readily detached from the matrix.

The foregoing descriptions and discussions of the character of the ventral integument in trilobites would have little or no scientific value, and would be about as useless as a minute analysis of the nodes and tubercles on the glabella of a *Phacops*, were it not for the fact that from them it is possible to reach some conclusions

[1] Op. cit. [2] Op. cit. [3] Op. cit.

regarding the myology of trilobites, and thus add something to the knowledge of their internal organization.

In the abdomen of a normal crustacean, as is well known, there is a pair of longitudinal dorsal muscles, the *extensors* of the abdomen. They divide into bundles, which are attached on the inner surfaces of the tergites of the somites. Likewise, on the ventral side, there is a larger pair of longitudinal muscles, the *flexors* of the abdomen, from which strands are given off and attached to each sternal arch.

FIG. 7.—*Ptychoparia striata*, Emmr. Dorsal view of the anterior portion of a specimen preserved as a cast in sandstone, and enlarged about two diameters. In the glabellar and anterior thoracic region, the filling of the body-cavity has been removed from the axial region, thus exposing the imprint of the hypostoma and ventral integument with its buttresses, or apodemal structures. Reduced from the original figure published by Jaekel. Cambrian: Bohemia.

The strands from one somite unite with the main bundles within the cavity of the next anterior somite. In a diagrammatic form, this disposition of the ventral muscles is represented in the accompanying figure (Fig. 8).

Now, since in crustacea it is of very common occurrence to have chitinous extensions of the integument within the body-cavity either to divide or to support organs, as well as for the attachment of muscles, it seems a necessary conclusion to refer the thickenings and buttresses on the ventral membrane of trilobites to the same class of structures, which are usually termed apodemes. With this interpretation, the median longitudinal ridge on the mesosternite of a trilobite would indicate the line of division between the two main ventral bundles. The first pair of oblique ridges on each side would delimit the main bundles and side strands, and show that these strands joined the main bundles obliquely within the cavity of the next anterior somite, as in ordinary crustacea. This accounts for the anterior truncation of the triangular area between the median and lateral ridges in the trilobite.

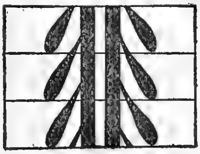


FIG. 8.—Diagram of the axial portions of three segments; showing the ventral abdominal muscles, the flexors, represented as two heavy longitudinal lines, together with the lateral strands attached to the sternal plate in each somite and continuing obliquely forward to their union with the main bundle in the cavity of the next anterior somite.

The nature of the outside pair of oblique ridges is not so plain. They may serve to divide the side ventral strands of the flexors from the bundle of muscles running from the proximal joints of the legs to the dorsal test, or they may simply mark the outside of the lateral strands.

The apodemes in general seem more strongly developed anteriorly in the thorax. Possibly, this condition may be explained on the basis that the ventral pair of the great flexor muscles received new strands at each segment from behind forward, so that near the cephalon they became large bundles for which progressively larger apodemes were formed.

It may be remarked, in conclusion, that a similar though apparently much simpler apodemal arrangement would be developed if the myology of the trilobites agreed with that of the theoretical crustacean ancestor, or that existing in some Isopods, Amphipods, etc., in which there are no large longitudinal bundles, but motion between the somites is effected by strands running from one segment to the next anterior. If viewed in this manner, there would necessarily be two median and two lateral strands. The previous explanation seems to be more in accordance with the structures actually seen in the trilobites, which in general possessed the power of enrolment to a high degree, and would be expected to have had a well-developed and efficient system of ventral muscles.

Summary.—The ventral integument in trilobites is a thin uncalcified membrane, which may be divided into pleurosternites and mesosternites, corresponding to the mesotergites and pleurotergites of the dorsal test, and like them connected segmentally by an interarticular membrane.

The mesosternites are usually marked by five longitudinal ridges, or buttresses, representing thickenings of the membrane, which may be homologized with apodemal structures in other crustacea, and not with the appendicular system.

These buttresses, or apodemes, include a single median one for each mesosternite, with two others on each side extending forward and obliquely inward, and enclosing sub-triangular or rhombic spaces.

The presence and disposition of these buttresses apparently afford information regarding the ventral myology of the trilobites. A pair of flexors is indicated, together with the lateral strands attached to each mesosternite and extending forward and inward to their union with the main bundles within the cavity of the next anterior somite.

EXPLANATION OF PLATES.

PLATE IX. TRIARTHRUS BECKI, Green.

FIG. 1.—A specimen viewed from the dorsal side; showing the extent of the antennules and the limbs on the right side. Enlarged about three diameters.

FIG. 2.—The ventral side of a pygidium; showing at the left of the median line the form and disposition of the exopodites and endopodites. The conical ends of the joints of the endopodites are provided with bundles of stiff hairs. Owing to the concavity of the specimen, it is impossible to show it all in proper focus. Enlarged ten diameters.

FIG. 3.—The posterior portion of an individual viewed from the ventral side; showing the distal ends of the exopodites, with their setæ and long fringes. Enlarged nearly ten diameters.

FIG. 4.—Dorsal view of an individual; showing the nine pairs of anterior thoracic limbs fully extended on the left side. The jointed endopodites and fringed exopodites may be clearly differentiated. Enlarged about three diameters.

FIG. 5.—A still further enlargement of some of the limbs of the preceding specimen; showing in more detail the distinctive characters and arrangement of the exopodites and endopodites. Enlarged about ten diameters.

Utica Slate, Ordovician: near Rome, New York.

This plate of illustrations, although very inadequately representing the actual objects, is introduced mainly to show the exquisite character of preservation of the specimens of *Triarthrus*.

PLATE X. TRIARTHRUS BECKI, Green.

Ventral view of an individual; showing the basal joints of the antennules, the biramous appendages, and the series of gnathobases. The appendages within the cephalon indicate their biramous structure like those over the thorax. They are therefore not simple as restored by Jaekel. The anal opening is shown near the extremity of the pygidium, but is obscure on account of not being in focus. Enlarged three and one-half diameters. (Original of fig. 1, pl. iv, vol. xv, American Geologist, 1895.)

Utica Slate, Ordovician: near Rome, New York.

PLATE XI. TRIARTHRUS BECKI, Green.

The ventral side of an individual prepared to show the character of the endopodites of the entire thoracic series. The gnathobases are distinctly seen extending obliquely inward from the sides of the axis; then follow, within the pleurosternal region, the sub-triangular joints of the endopodites with more slender distal joints. The origin and course of the antennules at the sides of the hypostoma are also shown. In the middle of the axis of the mid-thoracic region the ventral membrane is exposed, and the transverse limitations of the sternal arches and interarticular membrane may be observed. The arches show the buttresses or ridges of apodemal nature, as described in the text. Enlarged three and one-half diameters.

Utica Slate, Ordovician: near Rome, New York.

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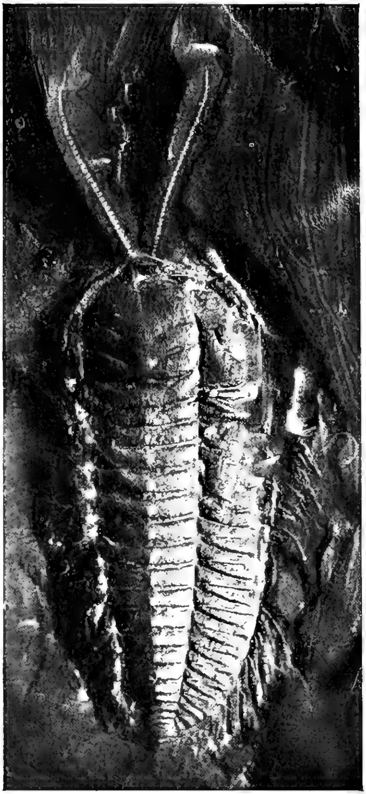

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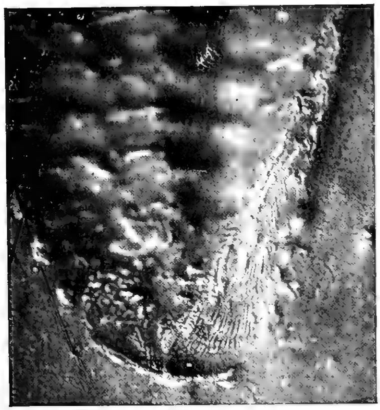

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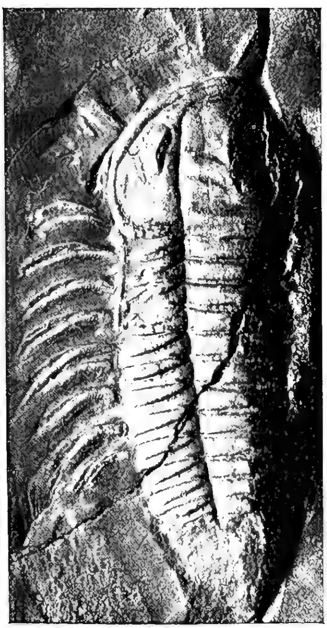
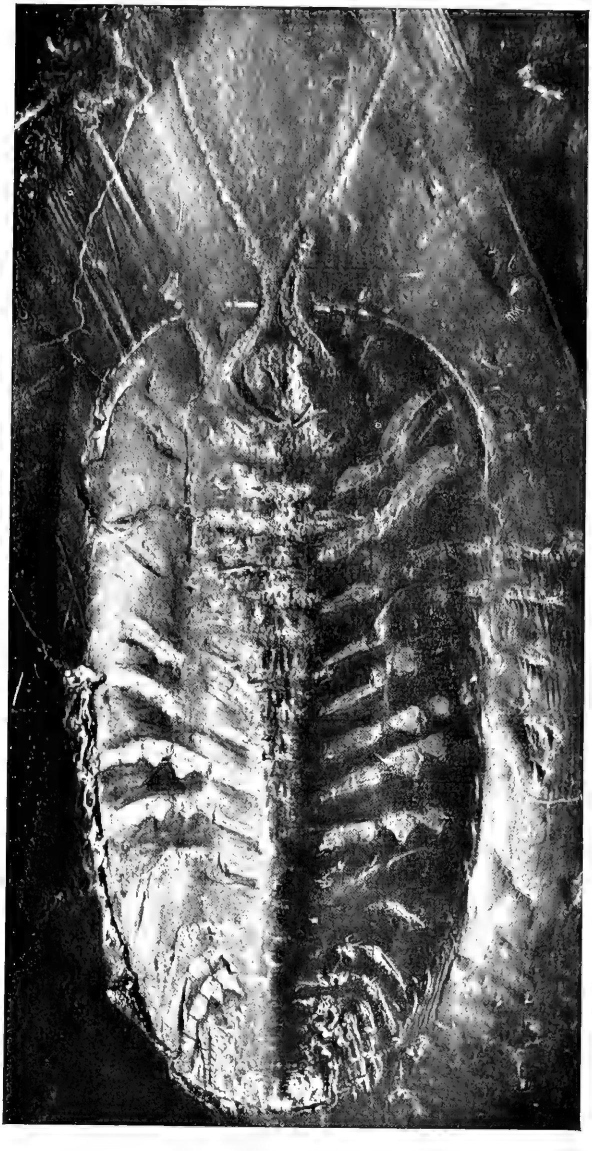


5

Appendages of *Triarthrus*.

Ventral side of *Triarthrus*.



Ventral side of *Triarthrus*.

IV.—On the Correlation of the Palæozoic Rocks of South Africa.

By Walcot Gibson, B.Sc., F.G.S.

THE publication of the Annual Reports for 1898 and 1899 of the Cape Geological Commission, coupled with the recent account of the geology of the Transvaal Colony by Dr. Molengraaff, and of which a short abstract has appeared in this Magazine,[1] adds considerably to the knowledge of South African geology. The succession of the rock formations at the Cape has been constantly used as a basis of classification for the rock systems south of the Zambesi. In his recent paper Dr. Molengraaff correlates the formations of the Transvaal Colony with those met with in the south-eastern provinces of Cape Colony, and emphasizes the fact that the three stages of the Pretoria, Dolomite, and Black Reef series of the Transvaal Colony may be compared with the Witteberg, Bokkeveld, and Table Mountain Sandstone series of the Cape. It may therefore be of service to show on what grounds this supposed correlation is based. To do this the succession at the Cape of the formations below the Beaufort Beds in the typical region of the south-eastern province will first be given. The grouping adopted by the Cape Geological Commission[2] is in descending order of sequence as follows:—

Table of Strata below the Beaufort Beds of Cape Colony.

Ecca Beds	Sandstones and shales with *Gangamopteris*.
Dwyka Series	Conglomerates and interbedded plant-bearing shales. Included boulders of distant origin.
Witteberg Beds	Mainly quartzites. *Spirophyton*.
Bokkeveld Beds	Shales, sandstones, and greywackes. Fossils of a Devonian facies.
Table Mountain Sandstone	Sandstones and quartzites with occasional shales.
Great Unconformity.	
Malmesbury Beds	Non-fossiliferous slates, phyllites, mica-schists, and quartzites. Granite, quartz-porphyry, and diabase as intrusive rocks.

From the Table Mountain Sandstone upwards there is no break in the succession of these deposits, which are several thousand feet thick and have been traced successively along a length of outcrop extending for over 100 miles; on the other hand, the hiatus between the Table Mountain Sandstone and Malmesbury Beds is unequivocal.

The whole series, excepting on Table Mountain and near the coast, are thrown into complex folds, admirably displayed in the Hex River Mountains and Klein Zwartebergen. Instances of complete inversion are not infrequent, and are particularly apparent north of the Zwartebergen. It is to the south of this range, in the Cango district, that some deposits of slates, dolomitic limestones, and sheared conglomerates and grits are met with overlying the Table Mountain Sandstone, but brought into this position by

[1] Geol. Mag., Dec. IV, Vol. VIII (1901), pp. 475–8.
[2] Reports, 1897 et seq.

inversion. Their exact position in the sequence is somewhat doubtful, but in the account of the report for 1898 it would appear that these Cango rocks are to be regarded as being older than the Table Mountain Sandstone, but newer than the Malmesbury Beds. Mr. E. J. Dunn regarded them as the equivalents of his Namaqualand schists; that is, as belonging to a formation older than the Malmesbury schists. The task of unravelling the stratigraphy of this complicated region remains to be worked out when better maps are available. At present it is very unsatisfactory, especially when these Cango rocks appear to bear considerable resemblances to some of the deposits of the Transvaal Colony, which are considered by Dr. Molengraaff to be the equivalents of the Table Mountain Sandstone and Bokkeveld Beds.

Between the areas occupied by these older rocks in the southern provinces and the Prieska division (described in the report for 1899), south of the Orange River, a tract of country over 200 miles wide intervenes, of which the geology has not been reinvestigated. A large portion of this area is occupied by the Karroo formation, but the older rocks emerge from beneath it along the edges of the Karroo basin and have not yet been examined by the members of the Cape Geological Commission along their whole length. So far as Messrs. Rogers and Schwarz have examined the formations in the district of Prieska, they have determined the following descending sequence, naming the rock groups in accordance with the nomenclature adopted by Stow for the regions north of the Orange River in Griqualand West.

TABLE OF FORMATIONS IN THE PRIESKA DISTRICT.[1]

Glacial Conglomerate and Shales	A coarse conglomerate resembling a grunde moraine. Overlying shales, carbonaceous and thin-bedded.
	Great Unconformity.
Matsáp Series	Quartzites and grits with pebbles of jasper rock. A sheared conglomerate at the base containing fragments of Griqua Town Series.
	Unconformity.
Griqua Town Series	Magnetic jasper rocks.
Campbell Rand Series	Limestones and quartzites.
Keis Series	Quartzites and mica-schists.

A granitic series is found in connection with the Keis group of rocks, but the relation of the two is uncertain. Messrs. Rogers and Schwarz state (p. 75 in report for 1899): "although the conclusion is mostly supported by negative evidence, it is probable that the whole granitic series was intruded among the Keis rocks, and that its gneissose structure was impressed upon it at the time when the dominant strike was given to the sedimentaries." The Campbell Rand and Griqua Town Series constitute a great mass of rocks, forming the Doornbergen and other areas in the district. Together with the Keis Series they appear to form an ascending sequence

[1] Report for 1899, Cape Geological Commission.

in the portion of the Doornbergen examined, but inversion due to overfolding occurs near Prieska Poort. The Matsáp Series are found lying in part unconformably on the dolomitic limestone and in part bounded by amygdaloidal lavas. The thickness of these beds is given by Messrs. Rogers and Schwarz,[1] as at least 3,000 feet, and the top is not seen.

The Glacial Conglomerate rests unconformably upon all the previous rocks. A description of this remarkable conglomerate has appeared elsewhere,[2] and need not be repeated. Stratification is generally absent and the boulders are of local origin; thus differing in a very marked manner from the Dwyka Conglomerate, with which, however, it seems to occupy a similar position in regard to the beds above, the conglomerate of both regions lying towards the base of the Ecca Series.

Such is the succession met with round Prieska. It is seen to differ materially from that of the southern provinces. Rocks resembling the Table Mountain Sandstone, Bokkeveld Beds, and Witteberg Series are absent, while the Glacial Conglomerate rests unconformably on a group of strata, of which the representatives may be found among the problematical rocks of the Cango district, and there only in a very imperfect degree.

In the south there is a great break between the Table Mountain Sandstone and Malmesbury Beds. Do these Prieska rocks bridge over the gap? It is interesting to find that the formations round Prieska have had intruded into them igneous rocks of pre-Karroo and post-Karroo ages. In all, Messrs. Rogers and Schwarz have detected five distinct types of igneous rocks, but their complete history has not been made out.

Considered as a whole, the geological record of the Palæozoic formations of Cape Colony as at present determined is very incomplete. Excepting the sequence from the Table Mountain Sandstone up into the Ecca in the south, the formations are met with only in fragments, and the data necessary to piece them together are wanting or remain to be discovered. It thus happens that the sequence of rocks in the south-east cannot be satisfactorily compared with that in the north-west.

It is a matter for regret that the relationships of the Cango deposits, Malmesbury schists, Table Mountain sandstones, and of the Prieska rocks, with their igneous history, have not yet been clearly determined. The Prieska rocks strike across the Orange River and are typically developed, judging from Stow's descriptions,[3] in Griqualand West, and with these the rocks above the famous 'Banket' formation of the Transvaal Colony have been compared.

[1] Report for 1899, p. 83.

[2] A. W. Rogers & E. H. L. Schwarz: Trans. Soc. Afr. Phil. Soc., vol. xi, pt. 2, pp. 113–120.

[3] Quart. Journ. Geol. Soc., vol. xxx (1874), pp. 581–680.

V.—A List of the 'Type,' Figured, and Described Fossils in the Norwich Castle Museum.

By Frank Leney, Assistant-Curator of Norwich Museum.

The generic and specific names and the horizons are those given by the authors. The numbers in square brackets correspond to those of the Museum register. A list of references and a history of the collections is given at the end. The localities, except where otherwise stated, are in Norfolk.

MAMMALIA.

Alces (*Cervus*) *bovides*, Gunn MS. (E. T. Newton). Left frontal and antler. E. T. Newton, "Vert. Forest Bed" (1882), p. 52. "Memorials of John Gunn" (1891), p. 80, pl. i (Cervidæ), fig. A. Forest Bed: Norfolk Coast. Gurney Coll. [326]. *Type.*

—— Left frontal and antler. "Memorials of John Gunn" (1891), pp. 80, 81, pl. v (Cervidæ), fig. 2 (as H.). Forest Bed: Bacton. Gunn Coll. B. [327].

—— vide *A. latifrons* (Johnson) [322].

Alces Cromptoni, Gunn MS.; vide *Alces*, sp. [240].

Alces latifrons (Johnson). Cranial fragment. Boyd Dawkins, "Cervidæ" (Pal. Soc., 1887), p. 2, pl. i, fig. 2 [Kessingland *errore*]. "Memorials of John Gunn" (1891), pl. v (Cervidæ), fig. 1 (*A.* (*Cervus*) *bovides*, Gunn MS.). Forest Bed: Pakefield. Gunn Coll. 139 [322].

—— vide *Cervus latifrons*, Johnson [245].

Alces, sp. Right shed antler. "Memorials of John Gunn" (1891), pl. v (Cervidæ), fig. 4 (*A. Cromptoni*, Gunn MS.). Forest Bed: Trimmingham beach. Rev. J. Crompton [240].

—— Shed antler. Ibid., p. 83, pl. v (Cervidæ), fig. 5. Forest Bed: Pakefield beach. Gunn Coll. 135 [324].

—— Antler. Ibid., p. 82, pl. vi (Cervidæ), fig. 4. Horizon and locality unknown. Gunn Coll. F. [304].

Arvicola (*Evotomys*) *intermedius*, E. T. Newton. Right lower jaw. E. T. Newton, "Vert. Forest Bed" (1882), p. 85, pl. xiii, figs. 12*a*, *b*. Norwich Crag: Bramerton, Norwich. Reeve Coll. [524].

—— Lower left anterior cheek tooth. Ibid., p. 85, pl. xiii, fig. 13. Norwich Crag: Thorpe, Norwich. Fitch Coll. [551].

Balænoptera ? sp. Vertebræ. Ibid., p. 108. Forest Bed: Bacton and Mundesley. Gunn Coll. [520, 522].

Bison bonasus, Linn., var. *priscus*, Boj. Horn-cores. E. T. Newton, Geol. Mag. [3], vol. vi (1889), p. 146. Forest Bed: Bacton and Happisburgh. Colman Coll. [482–486].

Cervus ardeus, C. & J. (Falconer MS.); vide *Cervus*, sp. [323].

Cervus bovides, Gunn MS. (E. T. N.); vide *Alces* (*Cervus*) *bovides* [326].

Cervus carnutorum, Laugel. Base of shed antler. Boyd Dawkins, Quart. Journ. Geol. Soc., vol. xxviii (1872), p. 409, woodcut. Chillesford Beds: Aldeby, Suffolk. Rose Coll. [287].

Cervus Dawkinsi, E. T. Newton. Portion of antler. Boyd Dawkins, "Cervidæ" (Pal. Soc., 1887), p. 10. Forest Bed: Corton, Suffolk. Colman Coll. [329].

—— vide *C. Fitchii*, Gunn MS. [303].

Cervus Fitchii, Gunn MS. (E. T. Newton). Left shed antler. E. T. Newton, "Vert. Forest Bed" (1882), p. 56 [Bacton *errore*]. Boyd Dawkins, "Cervidæ" (Pal. Soc., 1887), pl. ii, fig. 2 (*C. Dawkinsi*, Newton). "Memorials of John Gunn" (1891), pl. vi (Cervidæ), fig. 1. Forest Bed: Mundesley. Fitch Coll. [303]. *Type.*

Cervus Flowerii, Gunn MS.; vide *Cervus*, sp. [501].

Cervus latifrons, Johnson. Left frontal and antler. Randall Johnson, Ann. Mag. Nat. Hist. [4], vol. xiii (1874), p. 2, pl. i. Boyd Dawkins, "Cervidæ" (Pal. Soc., 1887), p. 4, pl. i, fig. 6 (*Alces latifrons*). Forest Bed: Happisburgh. Colman Coll. [245]. *Type.*

Cervus polignacus, Robert. Portion of shed antler. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 479. E. T. Newton, "Vert. Pliocene Deposits" (1891), pl. iv, fig. 12. "Memorials of John Gunn" (1891), pl. i (Cervidæ), No. 94. Forest Bed: Mundesley. Gunn Coll. 94 [316].

—— Portion of antler. "Memorials of John Gunn" (1891), pl. ii (Cervidæ), No. 95. Forest Bed: Mundesley. Gunn Coll. 95 [317].

Cervus Savini, Dawkins. Base of left antler. Ibid., pl. vii (Cervidæ), fig. 4. Forest Bed: Kessingland. Gunn Coll. 515 [314].

—— Portion of antler. Ibid., pl. vi (Cervidæ), fig. 2. Forest Bed: Mundesley. Gunn Coll. 116 [319].

—— Beam of antler. Ibid., pl. vii (Cervidæ), fig. 5. Forest Bed: Norfolk coast. Gunn Coll. 524 [309].

—— vide *Cervus*, sp. [306].

Cervus Sedgwickii, Falconer. Right antler. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 472, pl. xxxvii, fig. 1 (*Eucladoceros*). "Memorials of John Gunn" (1891), pl. iii (Cervidæ), No. 99. Forest Bed: Bacton. Gunn Coll. 99 [243]. *Type.*

—— Bases of shed antlers. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 475, pl. xxxvii, figs. 2, 3. Forest Bed (?): dredged off Norfolk coast. Rev. W. Foulger [241, 242].

—— Fragment of antler. "Memorials of John Gunn" (1891), pl. iii (Cervidæ), No. 100. Forest Bed: Mundesley. Gunn Coll. 100 [307].

—— Portion of antler. H. B. Woodward, Proc. Geol. Soc., Aug. 1893, vol. xlix, p. 146. Norwich Crag: Bramerton, Norwich. R. W. Hinton, Esq. [315].

Cervus tarandus, Linn. Frontals and antlers. Owen, "Brit. Foss. Mamm." (1846), p. 479, fig. 197. Flower & Lydekker, "Mammalia" (1891), p. 325, fig. 131 (*Rangifer*). Geikie, "Textbook of Geology" (1893), p. 1061, fig. 460. Bilney Moor, East Dereham. Rose Coll. [70].

Cervus verticornis, Dawkins. Left shed antler. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 479 (*Strongyloceros*). Boyd Dawkins, Quart. Journ. Geol. Soc., vol. xxviii (1872), p. 405, fig. 2. "Memorials of John Gunn" (1891), pl. ii (Cervidæ), No. 97. Forest Bed: Pakefield beach. Gunn Coll. 97 [305]. *Type.*

—— Right shed antler. "Memorials of John Gunn" (1891), pl. vii (Cervidæ), fig. 2. Forest Bed: Kessingland. Gunn Coll. 504 [325].

—— Portion of left shed antler. Boyd Dawkins, "Cervidæ" (Pal. Soc., 1887), p. 23, pl. v, figs. 1, 1*a*. Forest Bed: Corton, Suffolk. Colman Coll. [269].

—— Base of shed antler. "Memorials of John Gunn" (1891), pl. iii (Cervidæ), No. 107. Forest Bed: Mundesley. Gunn Coll. 107 [311].

—— vide *Cervus*, sp. [320].

Cervus, sp. Cranium and base of right antler. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 477, note 23. "Memorials of John Gunn" (1891), pl. iv (Cervidæ), No. 104 (*C. verticornis*). Forest Bed: Kessingland beach. Gunn Coll. 104 [320].

—— Cranium and bases of antlers. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 476, note 20. "Memorials of John Gunn" (1891), pl. iv (Cervidæ), No. 101. Forest Bed: Kessingland. Gunn Coll. 101 [321].

—— Cranium. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 476, note 21. "Memorials of John Gunn" (1891), pl. iv (Cervidæ), No. 102 (*C. Savini*). Forest Bed: Norfolk coast. Gunn Coll. 102 [306].

—— Left shed antler. "Memorials of John Gunn" (1891), pl. vi (Cervidæ), fig. 3. Forest Bed: Pakefield beach. Gunn Coll. E. [308].

—— Base of antler. Ibid., pl. vii (Cervidæ), fig. 3 (*C. Floweri*, Gunn MS.). Norwich Crag: Thorpe, Norwich. Gunn Coll. 501 [313].

—— Base of antler. Ibid., pl. iii (Cervidæ), No. 106. Forest Bed: Norfolk coast. Gunn Coll. 106 [318].

—— Fragment of antler. Ibid., pl. iii (Cervidæ), No. 98. Norwich Crag: Coltishall, Norwich. Gunn Coll. 98 [302].

—— Fragment of shed antler. Ibid., pl. ii (Cervidæ), No. 96. Norwich Crag: Horstead, Norwich. Gunn Coll. 96 [310].

—— Portion of antler. E. T. Newton, "Vert. Forest Bed" (1882), p. 63. "Memorials of John Gunn" (1891), pl. iii (Cervidæ), No. 105 (*C. ardeus*, Falc. MS.). Forest Bed: Mundesley. Gunn Coll. 105 [323].

Delphinus delphis, Linn. Vertebræ. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 79. Fluvio-marine Crag: Aldeby, Suffolk. Crowfoot and Dowson Coll. [507–511].

Elephas antiquus, Falc. Maxilla with molar teeth. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 182 [Ostend *errore*]. Leith Adams, "Brit. Foss. Elephants" (Pal. Soc., 1877), p. 39. Forest Bed: Happisburgh. Gunn Coll. 218 [1827].

—— Right upper molar. Leith Adams, "Brit. Foss. Elephants" (Pal. Soc., 1877), p. 32. Forest Bed: Bacton. Gurney Coll. 46 [1844].

—— Upper molar. "Memorials of John Gunn" (1891), pl. i, (Probos.), fig. F. Forest Bed: Happisburgh. Gunn Coll. 354 [1826].

—— Lower jaw. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 188. Leith Adams, "Brit. Foss. Elephants" (Pal. Soc., 1877), pp. 39, 55. "Memorials of John Gunn" (1891), pl. iii (Probos.), (prototype of *E. primigenius*). Forest Bed: Cromer Jetty. W. H. Windham, Esq. [1847].

—— Left ramus of mandible. Leith Adams, "Brit. Foss. Elephants" (Pal. Soc., 1877), pp. 39, 55. "Memorials of John Gunn" (1891), pl. iv (Probos.), No. 2 (*E. giganteus intermedius*). Forest Bed: Mundesley. Gunn Coll. 361 [1703].

—— Lower m.m. 2. Leith Adams, "Brit. Foss. Elephants" (Pal. Soc., 1877), p. 15. Forest Bed: Cromer. Fitch Coll. [1728, 1751].

—— Lower m.m. 3. Leith Adams, ibid., p. 18. Forest Bed: Norfolk coast. Gunn Coll. 304 [1970].

—— Right lower m. 3. Leith Adams, ibid., pp. 174–177, pl. xx, figs. 1, 2. "Memorials of John Gunn" (1891), p. 72 (*E. meridionalis*). Forest Bed: Corton, Suffolk. Colman Coll. [1788].

—— Lower m. 3 in jaw. Leith Adams, ibid., p. 39. Forest Bed: Overstrand. Gunn Coll. 306 [1754].

—— Lower m. 3. Leith Adams, ibid., p. 177. Forest Bed: Bacton. Gurney Coll. 19 [1786].

—— Molar tooth. Clement Reid, "Geology of Cromer" (1882), p. 119. "River Bed": Mundesley. Gunn Coll. [1971].

—— Molar tooth with glacial markings. "Witton, nr. Bacton, Norfolk." H. B. Woodward, Proc. Geol. Soc., Aug. 1893, vol. xlix, p. 146. Lower Boulder-clay: Sprowston, Norwich. J. Reeve, Esq. [1950].

—— vide *E. meridionalis*, Nesti [1835].

—— vide *E. (Loxodon) priscus*, Goldfuss [1832].

Elephas giganteus intermedius, Gunn; vide *E. antiquus*, Falc. [1703].

—— vide *E.* sp. [1765].

Elephas meridionalis, Nesti. Incisor tooth. Leith Adams, "Brit. Foss. Elephants" (Pal. Soc., 1881), pp. 9, 186. "Memorials of John Gunn" (1891), pp. 50, 70, 79, pl. v (Probos.), fig. 2. Forest Bed: East Runton. Sir T. F. Buxton, Bart., No. M. [1789].

le phas meridionalis, Nesti. Incisor tooth. Leith Adams, ibid., p. 186. "Memorials of John Gunn" (1891), p. 79. Dredged off Corton, Suffolk. Colman Coll. [1871].

—— Incisor of young animal. Leith Adams, ibid., p. 198. "Memorials of John Gunn" (1891), pp. 49, 78, pl. v (Probos.), fig. 1. Forest Bed: Bacton. Gunn Coll. 302 [1790].

—— Lower jaw. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 140. Leith Adams, ibid., p. 201. Forest Bed: Mundesley Cliff. R. Barclay, Esq. [1767].

—— Right ramus of mandible. Leith Adams, ibid., p. 201 [368 *errore*]. "Memorials of John Gunn" (1891), p. 71. Forest Bed: Norfolk coast. Gunn Coll. 367 [1732].

—— Right ramus of mandible. Falconer, "Pal. Memoirs" (1868), vol. ii, pp. 132, 140. Leith Adams, ibid., p. 199, pl. xxii, fig. 2. "Memorials of John Gunn" (1891), pp. 70, 71, 74, pl. iv (Probos.), fig. 1. Forest Bed: Bacton. Gunn Coll. 215 [1702].

—— Right ramus of mandible. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 132. Leith Adams, ibid., p. 201. "Memorials of John Gunn" (1891), p. 70. Forest Bed: Bacton. Gunn Coll. 215*a* [1694].

—— Left lower m.m. 2. Leith Adams, ibid., p. 188, pl. xxii, figs. 3, 3*a*. Forest Bed: Mundesley. Gunn Coll. 214 [1837].

—— Germ of m.m. 2. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 1, 1*a* [No. 11 *errore*], and "Pal. Memoirs" (1868), vol. i, p. 443; vol. ii, p. 133. Leith Adams, ibid., p. 188. Forest Bed: Norfolk coast. S. Woodward Coll. 4 [1784].

—— Lower m.m. 2. Leith Adams, ibid., p. 188. "Fresh-water deposits": Mundesley. Fitch Coll. [1750].

—— Right lower m.m. 2. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 3, 3*a*, and "Pal. Memoirs" (1868), vol. i, p. 444; vol. ii, p. 134. Leith Adams, ibid., p. 188. Forest Bed (?): Norfolk coast. S. Woodward Coll. 6 [1779].

—— Left lower m.m. 3. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 4, 4*a*, and "Pal. Memoirs" (1868), vol. i, p. 444; vol. ii, p. 134. Leith Adams, ibid., p. 189. Forest Bed: Norfolk coast. S. Woodward Coll. 10 [1785].

—— Left upper m. 1. Leith Adams, ibid., p. 192, pl. xxii, fig. 1. Forest Bed: Cromer. Fitch Coll. [1955].

—— Right and left upper m. 3. Leith Adams, ibid., p. 198. Forest Bed: Cromer beach. Gunn Coll. 219 [1699].

—— Left upper m. 3. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 14, 14*a* [No. 10 *errore*], and "Pal. Memoirs" (1868), vol. i, p. 447; vol. ii, p. 137, pl. viii, fig. 4. Leith Adams, ibid., p. 195. Forest Bed: Norfolk coast. S. Woodward Coll. 10*a* [1755].

Elephas meridionalis, Nesti. Portion of upper m. 3. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 15, 15*a* [No. 13 *errore*], and "Pal. Memoirs" (1868), vol. i, p. 447; vol. ii, p. 138. Leith Adams, ibid., p. 195. Forest Bed: Happisburgh. Old Coll. 13*a* [1772].

—— Portion of upper m. 3. Leith Adams, ibid., p. 198. Forest Bed: Norfolk coast. Gunn Coll. 220 [1763].

—— Upper m. 3. Leith Adams, ibid., p. 198. "Memorials of John Gunn" (1891), pl. i (Probos.), fig. H (prototype of *E. primigenius*). Forest Bed (?): Norfolk coast. Gunn Coll. 223 [1696].

—— Upper m. 3. Leith Adams, ibid., p. 198. "Memorials of John Gunn" (1891), p. 50, pl. i (Probos.), fig. D. Forest Bed: Bacton. Gunn Coll. 330 [1742].

—— Right upper molar. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, fig. 16, and "Pal. Memoirs" (1868), vol. i, p. 447; vol. ii, pp. 138, 182 (*E. antiquus*). Leith Adams, ibid., p. 39 (*E. antiquus*). Forest Bed: Happisburgh. S. Woodward Coll. 55 [1835].

—— Left upper molar. Leith Adams, ibid., p. 189. Forest Bed: Bacton. Gurney Coll. 9 [1777].

—— Abnormal left upper molar. "Memorials of John Gunn" (1891), p. 69. Norwich Crag: Horstead, Norwich. Gunn Coll. 334 [1574].

—— Left lower m. 1. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 5, 5*a*, and "Pal. Memoirs" (1868), vol. i, p. 445; vol. ii, p. 134. Leith Adams, ibid., p. 191. Forest Bed: Mundesley. S. Woodward Coll. 8 [1729].

—— Left lower m. 1. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 6, 6*a*, and "Pal. Memoirs" (1868), vol. i, p. 445; vol. ii, p. 135. Leith Adams, ibid., p. 191. Forest Bed: Mundesley. S. Woodward Coll. 7 [1723].

—— Left lower m. 2. Leith Adams, ibid., p. 198. Forest Bed: Mundesley. Gunn Coll. 311 [1693].

—— Right lower m. 2. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 7, 7*a*, and "Pal. Memoirs" (1868), vol. i, p. 445; vol. ii, p. 135. Forest Bed: Norfolk coast. S. Woodward Coll. 13 [1834].

—— m. 2. Leith Adams, ibid., p. 193. Forest Bed: Bacton. Gurney Coll. 22 [1769].

—— Right lower m. 3. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 18, 18*a*, and "Pal. Memoirs" (1868), vol. i, p. 448; vol. ii, p. 130, pl. viii, fig. 1. Leith Adams, ibid., p. 196. "Mammaliferous Crag": Thorpe Road, Norwich. S. Woodward Coll. [1570].

—— Right lower m. 3. Leith Adams, ibid., p. 197. Forest Bed: Bacton. Gurney Coll. 21 [1774].

(*To be continued.*)

NOTICES OF MEMOIRS.

I.—Additional Notes on the Cambrian of Cape Breton, with Descriptions of New Species. By G. F. Matthew, LL.D., F.R.S.C. (From Bulletin of the Natural History Society of New Brunswick, Canada, No. xx, vol. iv, pt. 5.)

THIS article deals with two subjects: (A) New Species of the Etcheminian or Basal Cambrian; (B) The Tremadoc Fauna. Under the first the development of the three perforate genera *Acrothyra*, *Acrotreta*, and *Acrothele* is described. The two first have been found in the lowest fossiliferous beds of the Basal Cambrian; from which they are traced upward, the first to *Protolenus* fauna (under *Paradoxides*), the second into the Ordovician. The first genus is specially prevalent in the Etcheminian or Basal Cambrian beds, one species being found in the Lower and another in the Upper Etcheminian beds.

A point worked out in this article is the change in size and form of *Acrotreta* as time went on. The first species known were about twice as wide as high, but towards the close of the lifetime of the genus the height and width were about equal, though in two species the height exceeded the width.

Acrothele was not found in the Lower Etcheminian, but comes in with the Upper Etcheminian fauna. Various species are quoted, ranging from this fauna to the top of the Cambrian.

There are described in this paper, of *Acrothyra* one new species and six mutations; of *Acrotreta*, one new species and two mutations; of *Acrothele*, two new species and one mutation.

The second part of the paper relates to species of Gasteropods and Trilobites recognized as representatives of the Tremadoc Fauna. *Asaphellus Homfrayi* is cited, also a new species, *A.* (?) *planus*. Species of *Triarthrus*, *Parabolinella*, and *Bellerophon* were found, also *Lingulella* and *Acrotreta*.

Six plates of figures are given to show the forms and characters of new species described.

II.—On the Relation of the Silurian and Ordovician Rocks of North-West Ireland to the Great Metamorphic Series. By Jas. R. Kilroe and Alex. McHenry.[1]

UPPER Silurian rocks, as high as Wenlock, have been metamorphosed along the Croagh Patrick range, which led to their inclusion in the great metamorphic group when the ground was originally mapped. The corresponding rocks of Wenlock age on the south margin of the Mayo and Galway Silurian basin, near Killary Harbour, are not metamorphosed, and rest unconformably upon the metamorphic group.

This stratigraphical break has for many years been supposed to form an insuperable objection to the acceptance of Murchison's

[1] Read before the British Association, Section C (Geology), Glasgow, Sept., 1901.

conjecture that the metamorphic rocks of Galway, Mayo, etc., are altered representatives of the Lower Silurian or Ordovician rocks. This, however, is not an obstacle, for a break, accompanied by overfolding and possibly metamorphism of Lower Silurian strata, has been proved to have occurred in Llandovery times, which admitted of Wenlock or possibly Tarannon beds being unconformable to unmetamorphosed Lower Silurian as well as to the metamorphic group. All this happened prior to a second violent disturbance and overfolding which accompanied the metamorphism of Wenlock strata already mentioned, and which occurred in Ludlow times.

A comparison of the Lower Silurian series in the west of Ireland with the metamorphic group of the same region and Donegal, shows so strong a resemblance between them—as regards the lithological characters of individual members in their original form, their order of succession, and certain peculiar coincidences of associated sedimentary components, described in detail in the paper—that it forms a creditable *primâ facie* argument for their correlation.

One instance may here be mentioned. At Westport and Achill Beg thick bands of fine conglomerate, associated with black slate, occur as an integral part of the metamorphic group, while on the south shore of Clew Bay thick bands of fine conglomerate—very similar in character to those in Achill Beg—occur in association with black slate, which, though sufficiently crushed to justify their inclusion by the original surveyors in the metamorphic ground, are now known to be of Lower Silurian age, identical with rocks of this age in Clare Island.

The chief objection to ascribing the metamorphic rocks of Mayo and Galway to the Lower Silurian age has been the present difference of condition between them and the fossil-bearing Lower Silurian rocks of the adjoining area. This difference seems to us explicable by conceiving that the great dislocation which occurred in Llandovery times, and occasioned an inversion of strata by overfolding at Salrock between the Killaries, carried unmetamorphosed Lower Silurian rocks about Leenane against and over rocks of, say, the same age, near Leenane, which had undergone metamorphism in connection with granitic intrusions. These may be seen in the vicinity of Kylemore. Unfortunately the great zone of break is now concealed by newer strata, and further is obscured and complicated by post-Ludlow faults.

III.—The *Glossopteris* Flora of Australia. By E. A. N. Arber, B.A., Trinity College, Cambridge.[1]

The *Glossopteris* flora is one of the most remarkable and widely distributed of fossil floras. Typical members, such as the fern-like plants *Glossopteris* and *Gangamopteris*, with the Equisetalean genus *Phyllotheca*, occur in rocks of Permo-Carboniferous age in India, Australia, South Africa, and South America, pointing to the

[1] Read before the British Association, Section C (Geology), Glasgow, Sept., 1901. See also Geol. Mag., Dec., 1901, p. 573.

former existence of a southern continent whose flora was for the most part distinct from that of the same age in Europe and North America.

In the Newcastle beds of New South Wales all the typical members of the flora occur without any admixture of northern types (e.g. *Lepidodendron* and *Sigillaria*), as has been recorded from similar beds in South Africa and South America. The flora of the Newcastle rocks is interesting botanically both on account of the wide distribution of the chief members, which show points of identity and unity in type with those of the Lower Gondwana of India and the Permian of Russia, and also from the morphological characters presented by many of the plants themselves. The collection which forms the subject of these remarks is in the Geological Museum, Cambridge, and is noteworthy as being one of the earliest (1839–44) formed of fossil plants from the continent of Australia.

REVIEWS.

I.—History of Geology and Palæontology to the End of the Nineteenth Century. By Professor Karl Alfred von Zittel. Translated by Maria M. Ogilvie-Gordon, D.Sc., Ph.D. 8vo; pp. 13, 562. (London: Walter Scott, 1901. Price 6s.)

THOSE who are not familiar with the German language will be grateful to Mrs. Ogilvie-Gordon for this translation of von Zittel's comprehensive and most interesting History of Geology, which was published two years ago. In the present work the text of the original has been curtailed by the omission of a chapter on Topographical Geology, and in a few places the subject-matter has been amplified—the changes being made with the author's approval.

Geology is rightly regarded as a modern science, for prior to the days of Hutton and William Smith there were no established principles for the interpretation of the facts. Nevertheless, we know that from the earliest days of which records are preserved, curiosity and interest were manifested in the rocks and stones that form the solid earth; and, while there were many shrewd guesses about former extensions of the sea and other physical changes, the observations were disconnected and the hypotheses for the most part were fanciful. Aristotle and Seneca in the earlier times; Leonardo da Vinci, George Bauer (Agricola), and Conrad Gesner prior to the seventeenth century, are among those whose views command most respect and admiration: but every philosopher who dealt with the origin or history of the earth appears to be mentioned by von Zittel. If we marvel at the erudition which has enabled the author to deal with these old writers and to point out so clearly the chief part which each has taken in the advancement of sound knowledge, we marvel still more when we come to later times with its multitude of workers and of books and papers, and find the same exhaustive treatment of the subject, with references necessarily brief, but yet clear, instructive, and impartial. While we may agree with the author that "With specialisation in geology and palæontology, the spring-time of the science was over," we must differ from him when he says, "The period was past when a man could mentally survey the whole field," for this is what he has done.

In his introduction the author deals with the *First Period*, or geological knowledge in the ages of antiquity; with the *Second Period*, or beginnings of palæontology and geology; with the *Third Period*, or heroic age of geology, 1790–1820; and more briefly with the *Fourth Period*, or modern geology. In the following six chapters the progress in various branches of geology is discussed, and there the labours of the heroes and all later workers are as fully acknowledged as possible. It is not a work, however, of which a summary can be given. It is itself a summary. Works of all kinds that have aided the progress of science are dealt with. Thus a considerable space is rightly given to Lyell's works and to the history of them, and reference is made to De la Beche's *Geological Observer*, "which is full of new observations and facts." In this connection we miss only the name of John Morris, whose Catalogue of British Fossils was surely worthy of mention.

In the references, however brief, there is generally some useful criticism or information; thus we read: "Following Rütimeyer's method, W. Morris Davis depicted the different stages in the development of a valley"; or again, "After Suess and Hyatt had opened the gates for the creation of new generic names, the palæontological literature of the Cephalopoda was inundated by innumerable new genera and species, most of them only narrowly defined."

A work so full of information, historical, geological, and even biographical, is unquestionably one which should be kept for reference by every geological worker. The translator has given thirteen portraits, including the author, von Buch, Cuvier, Murchison, Lyell, Owen, von Richthofen, Agassiz, and Suess; and we may heartily congratulate her on the production of a volume which, while it adds to the interest of geology, cannot fail to assist in the advancement of the science. H. B. W.

II.—The Foraminifera: an Introduction to the Study of the Protozoa. By Frederick Chapman, A.L.S., F.R.M.S., Palæontologist to the National Museum, Melbourne. 4to (28 × 18 cm.); pp. xvi, 354, with 15 Plates and 42 Figures. (London: Longmans & Co., Feb. 1902. Price 9*s.* nett.)

THANKS to Frederick Chapman, who has devoted so many years to the study of fossil and recent Foraminifera, and the rocks largely built up of them, we have now a volume dealing with the general subject. Of its usefulness there can be no possible doubt, for up to the present one has had to search for a special point through very nearly 4,000 tracts and separate publications. In this volume Mr. Chapman has digested all these various works into readable and accessible form, and rearranged the principal items of Sherborn and Tutkowski's Bibliographies under subjects, e.g., biology, shell morphology, classifications, technical, genera or special groups, special geological faunas, and recent faunas.

Starting with introductory remarks on the nature and occurrence of Foraminifera, their importance to the zoologist and geologist, structure, classification, and position of the group, he next deals with the shell-structure, reproduction, and plan of growth, gives a general sketch of the ideas of the early authors, and then devotes a chapter to each family. The various genera are defined, and a specific example is quoted and figured in outline; the geological range of the genus is given, and some general remarks accompany the species. It would have been useful if Mr. Chapman had always noted the original type-species of the genus, as well as what in his opinion is the typical form. But nowadays, there are many who regard an original type as of mere archæological interest, and those curious on either side can easily find out for themselves.

Following on with the geological range of the Foraminifera, we find an interesting sketch of this part of the subject, in which Mr. Chapman dismisses the useful Eozoön, the supposed organic origin of which gave rise to so much valuable research in microscopy, and casts well-founded doubts on the supposed pre-Cambrian bodies described as Foraminifera by Cayeux. Coming to Cambrian times, Chapman recalls many finds in beds of this age, both at home and abroad, and from that period onwards the Foraminifera have been rock-builders on a large, sometimes a gigantic scale. One need only instance the *Saccammina* and *Fusulina* Limestones of Carboniferous times, and the Nummulitic, Orbitoidal, and Alveolina Limestones of the Tertiary period.

Chapter xviii deals with the "geographical distribution, with remarks on the accompanying conditions of temperature, depth, and general environment," in which the various oceanic deposits are discussed. And chapter xix treats of the "collection, examination, and mounting of Foraminifera." The bibliography of subjects, concluding the volume, we have already alluded to.

The book is illustrated by fifteen plates, fourteen of which contain outline sketches of the typical forms of the various genera, and the odd one is a view of Dog's Bay, Galway, from one of Mr. Welch's well-known photographs. The outline sketches are, on the whole, sufficient for the purpose required, most of them being exceedingly characteristic. Forty-two other illustrations are given in the text, many of them being original; these include rock-sections, structures, apparatus, etc., and considerably enhance the value of the book. The author's style is clear and concise, and the descriptions of the genera give in as few words as possible just what is wanted. The book will find ready acceptance from a large body of students, and Mr. Chapman may be congratulated on opening his colonial career so auspiciously. The dedication to Professor Rupert Jones is particularly happy, and there is a pleasing reference to Professor Judd, whose laboratory afforded the author rich opportunities for work on this group of animals for many years.

C. D. S.

III.—Igneous Complex of Magnet Cove, Arkansas. By Henry S. Washington. Bull. Geol. Soc. Amer., vol. xi, pp. 389–416; 1900.

The Foyaite-Ijolite Series of Magnet Cove: A Chemical Study in Differentiation. By Henry S. Washington. Journ. Geol., vol. ix, pp. 607–622, 645–670; 1901.

THE great variety of igneous rocks, particularly of types rich in alkalies, developed at numerous centres in the eastern half of the North American continent, promise to yield many results of more than local interest to the petrologist, and Dr. Washington has now been engaged for some years in the study of certain important districts. From Essex County, Massachusetts, he has passed to the no less interesting area of Magnet Cove, Arkansas, originally described by the late J. F. Williams; and the results of his work are embodied in the two papers cited above. They include, firstly, an attempt to decipher the form and geological relations of the intrusive bodies, a matter of some difficulty owing to the poorness of the exposures; secondly, a re-examination of the rocks themselves, including a number of new chemical analyses, with calculations of the percentage mineral compositions and comparison with known types from other districts; and, finally, a chemical study of the principal rock-types as a natural group, with reference to their common origin by magmatic differentiation.

The outcrops of the chief igneous rocks of the Cove occupy an elliptic area, and divide, as shown on Williams' map, into an inner ellipse, composed of the most basic rocks, and an outer elliptic ring, consisting of rocks on the whole less basic and separated from the former by a ring of metamorphosed sediments. Williams believed the outer ring of igneous rocks to be of distinct origin from the inner body and of decidedly posterior intrusion, but Washington considers the whole to form a single group with intimate genetic relationship. The latter author, indeed, makes the outer ring continuous underground with the inner mass, the intervening metamorphosed sediments resting on the igneous rocks and representing the relics of what was once the cover of a single laccolitic intrusion. The argument here is scarcely convincing: although the metamorphosed rocks form a broken ridge, the area is not one of high relief, and it is noteworthy that none of the igneous rocks belonging to the outer ring are found, even as outliers, in the inner part of the Cove. Disregarding the metamorphosed rocks of the ridge, the various types met with are arranged roughly in concentric zones of decreasing basicity from centre to margin. Assuming the centre of the exposed surface to represent the centre of the laccolite, Washington points out that this disposition of the various rocks is the reverse of that described in some other igneous complexes, where the most basic type occupies the outermost ring. This evidently depends upon the interpretation adopted of the general structure of the mass, and an alternative reading of the observations does not seem to be excluded. The arrangement is apparently that of a dome. If we suppose the igneous rocks to have been themselves affected in some measure by the central uplift, we may perhaps plausibly picture the whole as consisting of two thin laccolites bent into a gentle dome and exposed by erosion which, in the centre of the area, has almost penetrated to the underlying sedimentaries. In this view the central exposure of rock would represent, not the centre, but the base of the lower laccolite; and the successive rings would represent, not inner and outer zones, but lower and higher strata.

Washington's petrographical investigation is of great value as defining with precision the several rock-types recognized by Williams. The outermost member of the complex is a *foyaite*, consisting of orthoclase (51·8 per cent.), nepheline (20·3), cancrinite, pyroxenes, etc. Next comes the rock for which the term *covite* is adopted: it has points of resemblance with the shonkinites of Montana, and may indeed be regarded as a nepheline-shonkinite. Here felspars (orthoclase and albite) still make up more than half of the mass; nepheline is reduced to 9 per cent., and the principal ferro-magnesian element is hornblende. In the third place comes the very interesting rock in which Williams described the now well-known pseudomorphs after leucite. This mineral is calculated to have made up 36·9 per cent. of the rock, nepheline being 25·5, orthoclase only 3·9, and the rest melanite and pyroxenes. This rock, which Washington names *arkite*, is, as Mr. Teall[1] has pointed out, almost identical with the borolanite of Sutherland, although the Arkansas type must have been richer in nepheline.

The three rocks enumerated, which make up the outer ring, are leucocratic (the white minerals predominating). The types met with in the inner part of the Cove are melanocratic (with preponderant dark minerals), and here felspar almost wholly disappears in favour of nepheline. The *ijolite* contains 38·7 per cent. of that mineral, a smaller proportion than in the typical ijolite of Finland; of the rest, pyroxenes make 42·8 per cent. and melanite 15·3. Another distinct type is recognized under the name *biotite-ijolite*. This carries nepheline 24·1 per cent. and orthoclase 4·8, the rest being diopside, melanite, and other dark minerals. Finally, there is a *jacupirangite* identical with the type-rock from Brazil; this has only 4 per cent. of nepheline, the remainder being chiefly pyroxene. This rock is not found (may possibly be concealed) in the centre of the area, where it should be expected, but is described from an outlying locality. The centre, however, is occupied by a mass essentially of magnetite, which produces great disturbance of the compass in its neighbourhood. The mineralogical, no less than the chemical, composition of the rocks indicates a very close consanguinity for the whole assemblage; but one may remark certain differences, especially in the ferro-magnesian silicates of the several types, which militate to some extent against the hypothesis of their origin by diffentiation *in sitû*.

In his general discussion of the mutual relationships of all these associated rocks the author is necessarily upon less firm ground;

[1] Geol. Mag., 1900, p. 389.

but he offers some suggestive considerations, and presents them with considerable originality of method. In setting forth the variations in chemical composition in the series he makes use of the graphical method, which, though it cannot of course lead to any result not contained in the columns of figures, will often bring out points which might otherwise escape notice. The abscissæ in his diagrams represent the radial distance of the several rocks from the centre or 'epicentre' of the complex, and it is considered that this expresses best the essential relations. The *a priori* objection to taking the silica for the abscissæ seems, however, to be without much force. As in many other cases, the order of increasing silica-percentage is manifestly the natural order in which to consider the several rocks (in this case corresponding with their disposition in space); if we arrange them in order of their content (say) of potash or soda, the whole is thrown into confusion. This, even apart from other considerations, places silica on a different footing from the other oxides. The choice of 'independent variable' cannot affect any very essential relations of the series. If, for instance, the silica and other oxides were all linear functions of some arbitrary variable, the other oxides would necessarily be linear functions of the silica. Washington's method, however, adapts itself well to the special case of differentiation in place with symmetrical arrangement.

It is to differentiation *in place* of a presumably homogeneous magma that the author ascribes this complex, notwithstanding the fact that the several rock-types are sharply separated from each other with little or no indication of transition. Taking into account the volume of each rock in the complex, he calculates the composition of the hypothetical initial magma, and finds that it does not agree at all closely with any member of the series. This result connects itself with the fact that the lines in the diagram of variation are not straight, or, in other words, the series is not a 'linear' one. Leaving out of account one rock, the covite, the lines are all smooth curves. The silica-line is inflected, being nearly horizontal in the middle part of the diagram, but descending gently towards the basic end and ascending rather steeply towards the acid end. The curves for alumina and the alkalies ascend gently and steadily, being only slightly curved. The curves for iron, magnesia, and lime, on the other hand, descend, and are decidedly convex upward. Covite does not fit into this comparatively simple scheme of variation, and the author regards it as probably originating by a *secondary* differentitaion, most likely from the foyaite magma. He attempts, indeed, to discover the complementary (more leucocratic) product, which may be represented by a variety of the foyaite. This latter rock, like the jacupirangite, has not been found in the place required by theory, and these irregularities, together with the generally sharp delimitation of the several concentric zones and certain points in the mineralogical constitution of the rocks, suggest to a critic that the differentiation may have been effected, at least in the main, prior to intrusion. In whichever way this minor question may be ultimately decided, the intimate genetic relationship connecting the several members of the series cannot be doubted, and this foyaite-ijolite complex affords one more illustration of a number of very different rock-types derived from a common source and disposed in a regular order. A. H.

IV.—Mémoire sur l'Histoire Géologique du Graphite. By Professor E. Weinschenck. Compte Rendu VIII Congrès Geol. Internat. Paris (1901).

GRAPHITE, graphitite, and graphitoid are varietal names for one mineral, graphite, based on subordinate characters such as lustre, fracture, and compactness. The principal known occurrences of graphite are reviewed. In *Ceylon* the graphite occurs in veins traversing the (intrusive) granulites, which show contact alteration in a very narrow zone immediately next to the veins. In this zone the felspars are altered to kaolin and nontronite (a hydrous ferric silicate), and flakes of graphite, needles of rutile, and individuals of sphene appear. At *Passau* in Bavaria the graphite occurs in lenticular masses and nests in gneissic rock of somewhat shattered character; but this rock is only charged with graphite when in contact with a neighbouring granite massif. The felspars are altered to kaolin and nontronite, and the graphite is accompanied by rutile. It is not a primary constituent of the gneiss, the flakes occurring always in the fissures and joints of the rock, which have, of course, originated since its crystallization.

The graphite of the Böhmerwald occurs in an essentially similar way, portions of gneiss rich in graphite having, however, a rather more stratified character, related to that of the beds of limestone present in the gneiss. The graphitic rocks are profoundly altered as at Passau, but are not clearly associated with a large mass of granite, although there are small bosses and dykes of granitic rock following the direction of the graphitic bands.

The occurrences of graphite in Cumberland and at Batongol in Siberia are referred to; the former occurs in association with an eruptive 'greenstone porphyry,' the latter in connection with a nepheline syenite. These two sources of graphite are no longer worked.

The alteration and impregnation products of the graphitic rocks are thus similar in Passau, Bohemia, and Ceylon. In Bohemia and Passau manganese peroxide is also abundant. So that the chemical processes must have been the same or similar in each case.

We might at first suppose that the hot magma in its ascent had distilled and volatilized large masses of organic matter, producing crystallized graphite. This would have liberated hydrogen and other reducing agents; instead we actually find that highly oxidized minerals accompany the graphite. More likely the penetration of carbon-bearing emanations or solutions is one of those post-volcanic phenomena which may follow the intrusion of igneous rocks. The metal-carbonyls — not yet met with in nature, however — easily decompose to metallic oxides and graphite with loss of CO_2. Professor

Weinschenck thinks that a reaction of this kind would explain all the peculiar characters of the graphite occurrences; the great alteration of the rocks is due to the quantity of CO_2 liberated, and the abundance of peroxides of heavy metals replacing silicates originally poor in them is also explained.

The common association of rutile with graphite may indicate the presence of cyanogen, which readily forms with titanium volatile combinations; the existence of nitrogen in the Ceylon graphite perhaps points in the same direction.

Passing to the Alpine localities (Styrian and Cottian Alps), we find that graphite occurs in beds of Carboniferous age where it is certainly of organic origin. It is usual to regard any metamorphic action in the Alpine regions—such as here the alteration of coal to graphite—as the result of dynamo-metamorphism. But the vegetable remains in the Styrian shales are not deformed, nor do the quartzites in the Cottian Alps show traces of crushing or brecciation. It is to a foliated gneiss (a foliated variety of the Central Alpine granites) associated with the altered Carboniferous beds that we must attribute the modifications met with in the Carboniferous sediments, by which the shales have been changed to chloritoid phyllites, the sandstones to quartzites, the coal to graphite.

So that when we review the chief localities for graphite we are struck with the fact that there is never a gradual passage from coal to graphite on the lines of regional metamorphism, but that when graphite is formed from coal it is a contact mineral. Graphite is not the final term of a series of carbonaceous rocks beginning with lignite and ending with anthracite.

Professor Weinschenck's researches show that the origin of graphite is different in different cases. It is clear, however, that in none of the above localities—and they are the most important known—is the graphite to be regarded as the representative of an ancient coal, *older than any rocks containing determinable fossils.* On the contrary, *graphite is usually an igneous emanation-product*; when of organic origin it occurs as a contact mineral in rocks much younger than the oldest fossiliferous strata. So that *the presence of graphite in ancient rocks does not push back the origin of life beyond the point at which we meet with the oldest authentic fossils.*

A. K. C.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—February 21st, 1902.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair.

Annual General Meeting.

The reports of the Council and of the Library and Museum Committee for the year 1901, proofs of which had been previously distributed to the Fellows, were read. In the first place a reference was made to the Address presented to His Majesty the King on the occasion of the death of Queen Victoria. After premising that the financial prosperity of the Society was again a matter for congratulation, the Council stated that the number of Fellows had undergone scarcely any change during 1901. The number elected was 52 (7 less than in 1900), of whom 34 qualified before the end of the year, making, with 17 previously elected Fellows, a total accession of 51 in the course of the twelve months under review. During the same period, the losses by death, resignation, and removal amounted to 55, the actual decrease in the number of Fellows being therefore 4 (as compared with a decrease of 10 in 1900).

The total number of Fellows, Foreign Members, and Foreign Correspondents, which on December 31st, 1900, was 1,334, had decreased to 1,329 by the end of 1901.

The balance-sheet for the year 1901 showed receipts to the amount of £3,503 17*s.* 8*d.* (including a balance of £388 14*s.* 10*d.* brought forward from the previous year), and an expenditure of £3,100 5*s.* 5*d.* The chief item of non-recurring expenditure was the sum of £508 11*s.* 11*d.*, being the cost of the redecoration of the Society's apartments. The balance remaining available for the current year was £403 12*s.* 3*d.*

The Council announced the completion of vol. lvii and the commencement of vol. lviii of the Society's Quarterly Journal.

It was stated that Mr. C. Davies Sherborn had undertaken to continue during the year 1902 the preparation of the Catalogue-slips which the Society supplies to the Regional Bureau of the International Catalogue of Scientific Literature. Further, the services of Mr. Sherborn had been secured for the preparation of a new Library Catalogue.

Reference was made to the work, which the Rev. J. F. Blake had offered to undertake without remuneration, and upon which he was now engaged, of editing and preparing for publication a catalogue of the type- and other important specimens in the Society's Museum. Reference was also made to the pamphlet by the Rev. J. F. Blake, entitled "Suggestions for Certain Improvements, 1901," which had been under the consideration of the Council.

The establishment of the Trust which will henceforward be known as the Daniel Pidgeon Fund was announced, and the list of awards of the various Medals and proceeds of donation funds in the gift of the Council was read.

The report of the Library and Museum Committee enumerated the extensive additions made to the Society's Library, and mentioned that considerable progress had been made with the work of glazing the drawers in the Museum.

The reports having been received, the President handed the Wollaston Medal, awarded to Dr. Friedrich Schmidt, F.M.G.S., of St. Petersburg, to Professor H. G. Seeley, for transmission to the recipient, addressing him as follows:—Professor Seeley,—

Friedrich Schmidt is our chief living authority upon the rocks and fossils of the Baltic Provinces of Russia. The work of ascertaining the order and organic remains of the richly fossiliferous strata of Esthonia, from the base of the Cambrian to the summit of the Devonian, originally commenced in broad outline by Eichwald, Pander, and others between the years 1830 and 1850, was taken up in great detail in 1853 by Schmidt, who was at that time Professor at the University of Dorpat. In the year 1856 he published his first work, "Die Silurische Formation von Estland, Nordlivland, und Œsel," which at once became the standard, and was referred to in detail by Murchison in his own paper on the subject in the Quarterly Journal of this Society for 1857. Even at this time Professor Schmidt had recognized between 400 and 500 fossils in these Esthonian rocks, had separated the Lower and Upper Silurian faunas, and had proved the existence of *Eurypterus* and *Cephalaspis* in the highest beds of his country.

For the next thirty years he continued these researches, and by the year 1882 he had completed a general survey of the region, had separated the Lower Palæozoic formations into the three faunal divisions of Cambrian, Ordovician, and Silurian, and distinguished some fifteen zones and sub-zones in the collective succession. He also published a map showing the distribution of the major zones, in readiness for the International Geological Map of Europe. Dr. Schmidt's results have enabled the whole of the Russian Palæozoic Series to be paralleled with the corresponding rocks of Scandinavia and other parts of the world.

In constant connection with the stratigraphical work, he has especially busied himself in the development and description of the palæontology of the Palæozoic succession. He has figured and described the Trilobites of the entire series, publishing the first part of his "Revision der Ostbaltischen Silurischen Trilobiten" in 1881, the fourth part in 1894, and the fifth part in 1898. He has also worked out the Eurypteridæ and the Leperditiadæ, the final parts of this work appearing in 1900. In 1888 he made known the discovery of *Olenellus* in the Lower Cambrian rocks of Esthonia, and he has subsequently described and figured the first Russian *Olenellus* (*O. Michwitzia*).

Dr. Schmidt's work, both palæontological and stratigraphical, bears the impress of unsparing labour, modest caution, and thoroughness; and the results that he has obtained have been invaluable in the development of our knowledge of the geology and fossils of the Baltic Provinces. He is one of the last survivors of the heroic age of geology, being the contemporary and occasional colleague of Eichwald, Pander, Kayserling, De Verneuil, Murchison, and Barrande. The award of our Wollaston Medal to this eminent Russian geologist and palæontologist is not only expressive of our hearty recognition of his lifelong devotion to the study of the rocks and fossils of his native land, but is also a grateful acknowledgment of the important services which he and his countrymen have rendered to the general advancement of geological science.

Professor Seeley replied in the following words :—Mr. President,—

Dr. Friedrich Schmidt desires to express his thanks for the honour of the award of the Wollaston Medal, and to say how much he regrets his inability to be present here, for he gratefully appreciates this expression of generous sympathy with his work. In early life he wandered through Siberia, where he learned the English language, which enabled him to contribute to the Society's Journal.

I have known Dr. Schmidt as Administrator of the Geological Museum of the Imperial Academy of Sciences of St. Petersburg, where I examined the materials described in his memoirs; and, in common with members of the International Geological Congress, I have been guided by him along the southern coast of the Gulf of Finland, from St. Petersburg to Œsel, to the principal scenes of his work in the Cambrian and Silurian rocks and Drift-deposits in the Eastern Baltic Provinces of Russia. And I may be permitted to say that all his work seems to me characterized by breadth of treatment and lucidity. In Schmidt the gifts and attainments of the naturalist illuminate the work of the geologist; and his search for truth never wearies and never hastes till all available facts are brought into illustrative relation with his research. His many-sided studies of nature have given a philosophical character to all Dr. Schmidt's contributions to science; and it is impossible not to realize that his scientific writings, which are many and valuable, give but inadequate expression to a personality which has powerfully influenced many to follow his methods and emulate his results. He has passed his 70th year, but works on, and looks forward to soon completing his final memoirs on the Trilobites.

He will warmly appreciate the terms in which the presentation of the Medal has been made, no less than the manner in which the Geological Society has endorsed the award of the Council.

The President then presented the Balance of the Proceeds of the Wollaston Donation Fund to Mr. Leonard James Spencer, M.A., F.G.S., of the Mineralogical Department, Natural History Museum, addressing him as follows:—Mr. Spencer,—

Your researches in Scientific Mineralogy during the last seven years constitute an important and solid contribution to natural knowledge. It is appropriate that the Council of this Society should mark their recognition of your labours by awarding to you the Balance of the Proceeds of the Wollaston Fund, which was instituted to promote researches concerning the mineral structure of the Earth.

In a series of papers on individual species you have shown yourself to be a master of the methods of crystallographic and mineralogical research, and you have applied these methods with signal success to the investigation of difficult minerals, some of which had baffled the efforts of previous workers.

Special interest attaches to those researches which you have carried out in collaboration with Mr. Prior, to whom this Fund was awarded two years ago, since these have led to the elucidation of species which had previously been misinterpreted, and have proved the identity of several rare minerals which were formerly ranked as different species. The most conspicuous instance is your joint study of Binnite, whereby that mineral, regarded for 45 years as a distinct species, was proved to be identical with the well-known mineral Tennantite.

Such researches naturally attract little attention outside the circle of mineralogists, but they are the sort of researches upon which accurate science is based.

The Council have pleasure in marking their appreciation of your patient and effective labours, by this award, and hope that their recognition of your work will encourage you to proceed with similar investigations.

In presenting the Murchison Medal to Mr. Frederic William Harmer, F.G.S., the President addressed him in the following words:—Mr. Harmer,—

The Council of this Society have awarded to you the Murchison Medal, in recognition of your long-continued labours among the Pliocene and later deposits of East Anglia.

In speaking of your earlier work, it is impossible to separate your name from that of Searles V. Wood, jun., who, I believe, discovered you on the Cromer coast nearly forty years ago, when you were trying to solve the riddle of its complicated Drifts. Wood, who had previously made a Drift Survey of the whole of Essex on the scale of 1 inch to the mile, soon enlisted your services in Norfolk while he continued his work in Suffolk; and in the course of about four years you were together able to bring before the British Association at Norwich a summary of the results at which you had arrived from the mapping of the Crag and Glacial Beds. Your map was published on a reduced scale by the Palæontographical Society in 1872, with a memoir in which you and Mr. Wood elaborated many points touched upon in your previous work. These original surveys formed an excellent basis for your further researches into the structure and method of formation of these deposits, and for the labours of all who have followed in your footsteps. Freed from the cares of business and of municipal duties, which occupied much of your time in earlier years, your attention has latterly been given to a study of the minuter divisions of the Crag Series, not only in this country, but abroad—in Holland and Belgium: thereby, dealing with the zonal succession in the Crag Series and with the distribution of molluscan life generally in the Pliocene Period, you have enlarged our knowledge of the physical and climatal conditions under which both Pliocene and Pleistocene deposits were laid down, and have drawn especial attention to the way in which meteorology can aid in the solution of geological problems.

While it is a matter for regret that Searles V. Wood, jun., did not live to receive from this Society any token of its appreciation of his labours, it is a great satisfaction to place this Medal in the hands of his partner, who has so strenuously carried on the work with which his name will always be associated.

Mr. Harmer replied as follows :—Mr. President,—

It is impossible to thank the Council as I could wish for the great honour that they have conferred on me, or yourself, sir, for the words which you have just spoken. The pleasure that this award gives to me has been much increased by your kind reference to my dear old master and friend, Searles V. Wood the younger, with whom, as you have said, I had so long the privilege of working: to whom, indeed, the credit of anything that I was able to accomplish in my younger days is largely due. I am glad to think that this Medal recognizes also the value of the far more important labours of the distinguished man to whose teaching and influence I owe so much.

I regret that during my best years the demands on my scanty leisure left me no time for geological investigation, and that I have only been able to return to it in the evening of life: first, because I can hardly expect to do much to show myself more worthy of this great distinction; and next, because I shall have to leave to my successors many important and interesting problems in East Anglian geology, in the solution of which I once hoped to have taken part.

The President then presented the Balance of the Proceeds of the Murchison Geological Fund to Mr. Thomas H. Holland, F.G.S., of the Geological Survey of India, addressing him in the following words :—Mr. Holland,—

The Records of the Geological Survey of India, the Journal of this Society, and other periodicals bear testimony to your scientific activity during the past decade. I can only refer to a few of your more important contributions to the advancement of science.

In your Memoir on the Charnockite Series you have made us familiar with the field-relations, the mineralogical composition, and the microscopic structure of an important and interesting group of Archæan rocks; in your contribution to the "Manual of the Geology of India" you have given us a valuable treatise on the natural history of Corundum; and in your paper on the Elæolite-Syenites of Sivamalai you have added a new group to the foliated crystalline series.

But you have not confined your attention to the crystalline rocks. In the "Report on the Geological Structure and Stability of the Hill-Slopes around Naini Tal" you have brought your geological knowledge to bear on questions affecting the security of life and property, and have laid down general principles which must be of great utility to all those who are responsible for the safety of the inhabitants of those hilly districts, in which denudation is going on with exceptional rapidity.

I have much pleasure in handing you the Balance of the Murchison Geological Fund, which has been awarded to you by the Council of the Geological Society in recognition of your valuable contributions to Indian Geology.

In handing the Lyell Medal awarded to Mr. Richard Lydekker, B.A., F.R.S., to Dr. F. A. Bather for transmission to the recipient, the President addressed him as follows :—Dr. Bather,—

Mr. Lydekker's labours in the domain of Vertebrate Palæontology commenced, I believe, with a study of the Siwalik fossils, which resulted in numerous and valuable additions to the classic work of Falconer & Cautley on the Siwalik Fossils.

Many other Tertiary Vertebrata from various parts of India and Burmah, from Perim Island, Sind, the Nerbudda, and the Irrawaddy Valley, have been examined and described by him. He has also given us an account of the Pleistocene fauna of the Karnul caves, and has contributed to our knowledge of Indian Mesozoic Reptilia.

During his residence in India as an Officer of the Geological Survey he was necessarily much occupied with field-work; and we have to thank him for a detailed account of the vast mountainous area comprised within the territories of Kashmir.

Since his return to this country he has not been idle. He has contributed no less than ten volumes to the Official Catalogue of the British Museum; he has visited the Museums of Argentina and added much to our knowledge of the remarkable Tertiary fauna of South America; and he has furnished to this and other Societies numerous descriptions of Vertebrata from the Mesozoic and Tertiary formations of various countries. His extensive knowledge of fossil forms has enabled him to contribute to two of the most remarkable zoological books published during the last decade of the nineteenth century. I refer to "Mammals, Living and Extinct," by Sir William Flower and him, and to the "Dictionary of Birds" by Professor A. Newton. Of late years he has devoted himself more especially to the study of recent forms; but in his work on the Geographical History of Mammals he has successfully brought his wide knowledge of the mammalian life of past times to bear on the important question of geographical distribution.

As an old fellow-student of his at Cambridge it gives me the greatest pleasure to be the means of transmitting to him the Lyell Medal on behalf of the Council of the Geological Society. In making the award the Council desire especially to commemorate the important services which he has rendered to Vertebrate Palæontology.

Dr. Bather, having expressed on behalf of the recipient the latter's regret that an engagement at Norwich prevented him from being present in person to receive the Medal, read the following communication from Mr. Lydekker:—

"The award of a Lyell Medal would under any circumstances be a cause of great gratification to the recipient. But I have special reason to be gratified at the reward that the Council have been good enough to bestow on me, because in matters scientific I seem to have passed unconsciously through a kind of evolutionary process, and to have departed further and further from the line of study connected with the Geological Society. During my term of service on the Geological Survey of India I was largely occupied with Geology proper, although devoting a considerable proportion of my time to Vertebrate Palæontology. For several years after my return to this country that fascinating subject occupied the greater share of my attention. But of late years I have been led by the force of circumstances to transfer my time more and more to recent animals and geographical distribution. Moreover, I regret to say, much of my time has been given to popular or semi-popular writing rather than to strictly scientific work. Under these circumstances it is especially gratifying to find that the Geological Society is not unmindful of my past efforts to add to our knowledge of extinct Vertebrates; a task which I hope, as opportunity occurs, may to some extent be resumed in the future. To you, sir, as representing the Council, I have the pleasure of tendering my best thanks for the honour now conferred upon me; and I may add that my pleasure is intensified by receiving the award at the hands of a Cambridge contemporary who has risen to the distinguished position now occupied by yourself."

The President then handed another Lyell Medal, awarded to Prof. Anton Fritsch, F.M.G.S., of Prague, to Prof. H. G. Seeley for transmission to the recipient, addressing him in the following words:—Professor Seeley,—

The Council of the Geological Society have awarded a Lyell Medal to Dr. Anton Fritsch, of Prague, in evidence of their appreciation of the value of his published works upon the Palæontology of Bohemia. In 1872, 1878, and 1887 Professor Fritsch gave us a series of volumes on the Cephalopoda, Reptiles, Fishes, and Crustacea of the Bohemian Cretaceous Rocks. But he is best known by his researches in Palæozoic Palæontology. Twenty years ago, after the publication of the first results of his labours on the Fossils of the Pilsen Coal-basin, this Society made to him an award from the Lyell Geological Fund. It is fitting, therefore, that he should receive the Lyell Medal on the completion of this great work, which represents twenty-five years of strenuous labour, and has gained for its author a position of great eminence in the palæontological world.

Much of the material with which he has had to deal would probably have been neglected by less accomplished observers. By careful drawing with his own hands, and by the aid of electrotype reproductions of perishable parts, he has brought vividly before us a new Permian terrestrial fauna, remarkable for its labyrinthodontia, fishes, arachnida, insects, and myriapoda. Professor Fritsch has not only described a vast amount of new palæontological material, but he has also used the knowledge thus gained for the purpose of elucidating the affinities of the different extinct groups with each other and with their nearest living allies.

His studies of Labyrinthodontia demonstrated the wide range of structure in animals included in that group, and suggested the approximation of the several subdivisions which he described to different orders of reptiles.

In conveying this Medal to Dr. Fritsch I ask you to express to him our sympathy with his labours in palæontology which have been carried on for fifty years, and our satisfaction at the completion of his great work on the Permian Fauna of Bohemia.

Professor Seeley replied as follows:—Mr. President,—

It is a great pleasure to receive the Lyell Medal on behalf of Professor Fritsch. He has successfully overcome difficulties in the mineral condition of material which might have stopped a less resolute man. His work, enriched with all the learning which a comparative anatomist could bring to palæontological problems, will, I believe, always rank as one of the more important contributions to knowledge made in the latter half of the nineteenth century. The Medal came as a happy surprise to Professor Fritsch, and he writes to me:—

"In awarding to me the proceeds of the Lyell Fund twenty-five years ago the Society encouraged me in the heavy work of describing the rich fauna of the Permian strata in Bohemia, which I have happily finished after thirty years of labour.

"This second award will strengthen me to devote the rest of my life to further elaboration of the beautiful palæontological materials in our Museum. The new revision of the Carboniferous Arachnida and descriptions of two large Saurians from our Chalk formation, on which I am at work, will be the best thanks that I can pay to the Geological Society for this generous gift."

The President then presented the Balance of the Proceeds of the Lyell Geological Fund to Dr. Wheelton Hind, F.R.C.S., of Stoke-on-Trent, addressing him as follows:—Dr. Wheelton Hind,—

The Council of the Society have awarded to you the Balance of the Proceeds of the Lyell Fund as a mark of their appreciation of your enthusiastic labours among the Carboniferous rocks of this country. During the past twelve years, while residing in the interesting region of the Potteries, and largely occupied in arduous professional work, you have found time for a detailed study of the rocks and fossils of your district, and more especially of the neglected lamellibranchs of the Coal-measures. Extending your labours into bordering and even distant Carboniferous areas, you have not only enriched our knowledge of the stratigraphical divisions, but you have initiated a study of the life-zones—a study which has borne good fruit, and in which we anticipate from you further important results. In addition to this, we are further indebted to you for the monographs on Carboniferous Mollusca which you have contributed to the Palæontographical Society.

In handing the Proceeds of the Barlow-Jameson Fund, awarded to Mr. William Maynard Hutchings, F.G.S., of Newcastle-upon-Tyne, to Mr. George Barrow for transmission to the recipient, the President addressed him as follows:—Mr. Barrow,—

In the midst of a busy professional life Mr. Hutchings has found time to carry out a series of laborious petrographical researches, and to contribute a number of important papers to the Geological Magazine and other scientific journals.

He has especially directed his attention to the composition of the finer-grained sedimentary rocks, and to the changes which are produced in them by normal decomposition and contact-action. The rocks on which he has worked have been comparatively neglected by petrologists, in consequence of the difficulties attending their investigation, but he has shown that, by the use of suitable sections and very high powers, these difficulties can be successfully surmounted.

The Council of the Geological Society have awarded to Mr. Hutchings a grant from the Proceeds of the Barlow-Jameson Fund, as a mark of their appreciation of his contributions to petrographical science, and as an expression of the hope that, in the future as in the past, he will be able to carry on the researches which have thrown so much light on the natural history of our sedimentary rocks.

The President then proceeded to read his Anniversary Address, in which he first gave obituary notices of several Fellows deceased since the last annual meeting, including Dr. G. M. Dawson (elected in 1875), Professor E. W. Claypole (el. in 1879), the Hon. Clarence King (el. in 1874), Mr. J. H. Blake (el. in 1868), Professor Ralph Tate (el. in 1861), Mr. J. Shipman (el. in 1885), the Rev. Frederick Smithe (el. in 1858); Professor Gustav Lindström (el. For. Memb. in 1892), and Baron A. E. Nordenskiöld (el. F.M. in 1880).

He then dealt, in continuation of the address delivered last year, with the evolution of petrological ideas as regards the sedimentary and metamorphic rocks.

The influence of the growth of knowledge as to the nature of the sedimentary rocks, the chemical and physical processes involved in their formation, and the deposits now forming, was traced in more or less detail. Special attention was directed to the importance of experimental research, suggested and controlled by an intimate knowledge of the facts of geology.

It was pointed out that the natural history of our sedimentary formations requires for its elucidation, not only a study of the phenomena taking place in sea-basins and areas of open drainage, but of those of desert regions and areas of closed drainage; and that the recognition of this fact by Ramsay and others marks a distinct advance in the evolution of ideas. The researches in desert regions by W. T. Blanford, O. Fraas, Schweinfurth, J. Walther, and others were referred to, and their results epitomized.

In the part relating to crystalline schists it was pointed out that, if gneissose rocks of original igneous origin be left out of account, the remainder consist for the most part of metamorphic rocks; and the growth of opinion on the subject of metamorphism as applied to crystalline schists was briefly traced. The idea that mixed rocks might be formed by the intrusion of one kind of igneous rock into another or into a sedimentary rock was favourably reviewed, and its bearing on the origin of certain crystalline schists was indicated.

The theory of dynamo-metamorphism was commented on; and it was pointed out that the advocates of the theory had not suggested that the deformation which resulted in the production of holo-crystalline schists took place at ordinary surface temperatures.

In conclusion it was pointed out that, although great progress had been made in the interpretation of crystalline schists, our stock of ideas was insufficient to furnish a complete and satisfactory account of their origin.

The ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—*Council:* F. A. Bather, M.A., D.Sc.; W. T. Blanford, LL.D., F.R.S.; Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S.; Professor E. J. Garwood, M.A.; Sir Archibald Geikie, D.Sc., D.C.L., LL.D., F.R.S. L. & E.; Professor T. T. Groom, M.A., D.Sc.; Alfred Harker, Esq., M.A.; R. S. Herries, Esq., M.A.; W. H. Hudleston, Esq., M.A., F.R.S., F.L.S.; Professor Charles Lapworth, LL.D., F.R.S.; Lieut.-Gen. C. A. McMahon, F.R.S.; J. E. Marr, Esq., M.A., F.R.S.; Professor H. A. Miers, M.A., F.R.S.; Right Rev. John Mitchinson, D.D., D.C.L.; E. T. Newton, Esq., F.R.S.; G. T. Prior, M.A.; D. H. Scott, M.A., Ph.D., F.R.S., F.L.S.; Professor H. G. Seeley, F.R.S., F.L.S.; Professor W. J. Sollas, M.A., D.Sc., LL.D., F.R.S.; Arthur Sopwith, Esq., M. Inst. C.E.; J. J. H. Teall, Esq., M.A., F.R.S.; Professor W. W. Watts, M.A.; Henry Woodward, LL.D., F.R.S.

Officers:—President: Prof. Charles Lapworth, LL.D., F.R.S. *Vice-Presidents:* Sir Archibald Geikie, D.Sc., D.C.L., LL.D., F.R.S. L. & E.; J. E. Marr, Esq., M.A., F.R.S.; Professor H. A. Miers, M.A., F.R.S.; Professor H. G. Seeley, F.R.S., F.L.S. *Secretaries:* R. S. Herries, Esq., M.A.; and Professor W. W. Watts, M.A. *Foreign Secretary:* Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S., F.L.S. *Treasurer:* W. T. Blanford, LL.D., F.R.S.

II.—February 26th, 1902.—Prof. Charles Lapworth, LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. "On some Gaps in the Lias." By Edwin A. Walford, Esq., F.G.S.

The author's endeavour is to prove gaps in the stratigraphical succession of the Lias, involving the removal of zones or parts of zones, and also to prove palæontological gaps by the abrupt appearance of many new genera of mollusca.

The Middle Liassic ferruginous limestone of the zone of *Ammonites spinatus* he states to be mainly made up of a kind of crinoid (ferrocrinoid). The zone may be divided into

2. The Ferrocrinoid bank—upper. 30 feet.
1. The *Spirifer oxygona* beds—lower. 20 feet.

The upper division varies from 30 feet at an altitude of 700 feet to 6 feet at the altitude of 350 feet on the edges of the Cherwell Vale, owing to waste by drainage. The upper zone is of great thickness and importance in Oxfordshire and Yorkshire (Cleveland), but almost absent in Dorset, Somerset, and Gloucestershire, where the fauna of the lower *Spirifer oxygona* beds prevails. The ironstone is thickest towards the escarpment on the west of the Cherwell Vale; on the east side of the vale it loses both in type and importance. At Bloxham a course of ferruginous limestone is made up of stems of the ferrocrinoid in great part, but near the top it becomes a pink compact limestone, full of fossils of the zone of *Ammonites communis*: the intermediate transition-bed and zone of *Ammonites serpentinus* having been removed by inter-waste rather than by contemporaneous erosion.

A transition-bed between the Middle and Upper Lias shows a great incoming of new forms. They are no doubt developed outside lines of known strata.

A third gap, measured by the occurrence of a thin bed of Pentacrinite-limestone, is in the zone of *Ammonites communis.*

The '*spinatus*-ironstone' is believed to lose in thickness on the side of a divide away from the main west-to-east dip. On the Northamptonshire side of the Cherwell, where the slope is to the west, and hence opposite to the general dip, the beds are thin, although the argillaceous beds are better preserved.

2. "On the Origin of the River-System of South Wales, and its Connection with that of the Severn and Thames." By Aubrey Strahan, Esq., M.A., F.G.S.

The southerly courses of some rivers from the Usk to the Ogmore are described, and shown to be independent of both the east-and-west folding and the north-north-westerly faulting of the rocks on which they lie. Farther west the drainage system takes a different direction, the rivers coinciding so closely with a set of west-south-westerly disturbances as obviously to have been determined in direction by them.

Of the three systems of disturbance alluded to, the east-and-west (Armorican) folding was pre-Triassic; it marks a period of compression with impulse from the south, and though it reached great intensity in Devon, Somerset, and South Wales, it died away in Central Wales. The north-north-westerly (Charnian) faulting, though partly of pre-Triassic age, was renewed in post-Eocene times, and is manifested over much of the British Isles. It marked periods of relief from pressure, and of subsidence. The west-south-westerly (Caledonian) folding was the latest; it marked a period of compression, with impulse from the north, and displayed greater energy in Central than in South Wales. It gave rise to a series of subsidiary disturbances in the latter region, and initiated and controlled the river-system. The ignoring by the rivers of the structures due to the earlier disturbances is attributed to the Palæozoic areas having been overspread by Upper Cretaceous rocks at the time of the initiation of the river-system.

The eastward course of the Upper Severn is attributed to the upheaval of a main axis (now the main water-parting) in Central Wales. Its deflection to the south and south-west was due to the formation of an anticline in the Chalk, which must have been parallel to, but a little west of, the present Chalk escarpment, and which was parallel to, and contemporaneous with, the Caledonian disturbances in Wales.

This anticline, acting in combination with the Armorican folding displayed in the London and Hampshire basins initiated the systems of the Thames and Frome. Those systems were initiated in post-Oligocene and pre-Pliocene times, and the same age is inferred for the systems of South Wales and of the Severn.

III.—March 12th, 1902.—Sir Archibald Geikie, D.C.L., LL.D., F.R.S., Vice-President, in the Chair. The following communications were read:—

1. "The Crystalline Limestones of Ceylon." By Ananda K. Coomára-Swámy, Esq., B.Sc., F.L.S., F.G.S.

The crystalline rocks of Ceylon may be divided into three series:—

(1) The Older Gneisses.
(2) The Crystalline Limestones.
(3) The Granulites (Charnockite Series)—pyroxene-granulite, leptynite, etc. A local subdivision of this series is the Point de Galle Group—wollastonite-scapolite-gneisses, etc.

The crystalline limestones of Ceylon are intimately associated with the banded pyroxene and acid granulites (Charnockite Series).

They form bands with outcrops from a few feet to over a quarter of a mile in width, interbedded with the granulites. The limestones themselves have a banded structure (foliation) parallel to that of the granulites and to the boundaries. This foliation of the limestone depends on variations in structure, amount of accessory minerals, and relative proportion of calcite and dolomite. The grain is coarse, sometimes exceedingly so. Parallel and graphic intergrowths of calcite and dolomite are very characteristic. The most abundant accessory minerals are olivine, phlogopite, pink or violet spinel, diopside, pyrite, and blue apatite; less common are amphiboles, clinohumite, green spinel, etc. The most characteristic contact-minerals are diopside, amphibole, green spinel, and greenish micas; and, rather in the granulite than the limestone, scapolite, phlogopite, diopside, sphene. There occur also in the limestones, nodular mineral aggregates composed of characteristic minerals such as diopside, phlogopite, blue apatite, and spinel.

There are often transitions between the limestones and granulites. In some other cases a zone of green rocks (with diopside, dark mica, amphibole, and green spinel) intervenes. Bands (sills) of granulite of various width, down to less than a foot, may occur in the limestone, and are parallel to the foliation and general strike. These show peripheral transitions to the limestone by incoming of original calcite and the appearance of lime-silicates, or are separated from it by a zone a few inches wide, in which the minerals diopside, amphibole, and green spinel are characteristic.

Some interrupted sills are described, and compared with the interrupted dykes of nepheline-syenite in the crystalline limestones of Alnö, described by Professor Högbom. A sill may thus be continued along the strike as a series of lenticles. Elsewhere quite isolated masses of pyroxene-granulite occur as inclusions in the limestone.

Although the relation of the granulites to the limestones is on the whole intrusive, the two rocks in their present condition are essentially contemporaneous, and seem alike to have consolidated from a molten magma. The calcite occurring in the granulites near the contact has all the appearance of an original mineral. The foliation of the limestone is regarded as a sort of flow-structure, and corresponds with that of the granulites to which it is always parallel. That the foliation does not result from the action of earth-movements on a solid rock is shown by this, that the very minerals whose variable distribution is one of its chief causes, have certainly not been affected by deforming earth-movements, nor are they such as to have been produced by these; moreover, in this respect a distinction cannot be made between the limestones and granulites, which would necessarily have suffered alike had they been subjected to deforming strains since the consolidation of the latter. The original nature of the limestones is less evident: they may have been sedimentary or tufaceous, and, if so, subsequently softened and metamorphosed; or possibly *ab initio* truly igneous rocks, and related to the charnockite-magma. Reasons for and against these views are given.

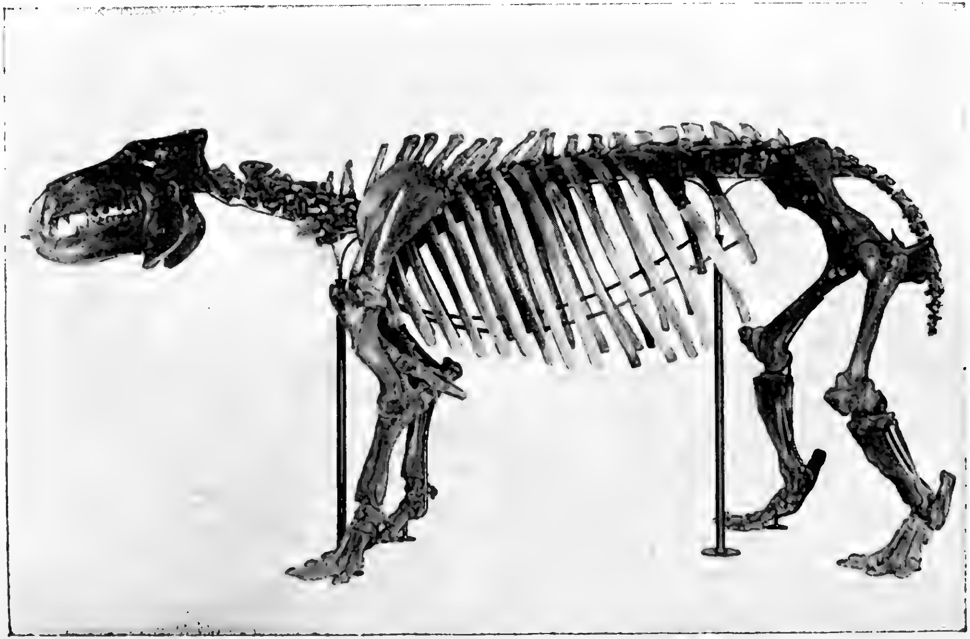
The relations between the crystalline limestones and nepheline-syenites of Alnö have suggested to Professor Högbom that perhaps the limestones may have been a product of the nepheline-syenite magma there.

The author feels sure that the crystalline limestones of Ceylon have not arisen by the alteration of the basic lime-silicates of the pyroxene-granulites, although Professor Judd has advanced this theory in connection with the crystalline limestones of Burma, which seem to resemble those of Ceylon in many ways.

2. "On Proterozoic Gasteropoda which have been referred to *Murchisonia* and *Pleurotomaria*, with Descriptions of New Subgenera and Species." By Miss Jane Donald. (Communicated by J. G. Goodchild, Esq., F.G.S.)

Many of the Palæozoic shells referred to *Murchisonia* do not agree with the type, and there are at least two separate groups distinguished by the outer lip. The typical growth has a slit, the other merely a sinus. As the outer lip is rarely well preserved, it is difficult and sometimes impossible to decide whether a particular individual belongs to one or other of these two types. With regard to these shells, two important questions require to be answered. Firstly, whether the slit or the sinus characterizes the more primitive type; and secondly, whether the elongated *Murchisonia* and the shorter *Pleurotomaria* are both derived from the same stock, and which of them appears the earlier. Before considering the British evidence the work of foreign palæontologists is reviewed by the authoress. From the material at present available, in the British Isles as well as in America and the Baltic Provinces, elongated forms with a sinus precede those with a slit. There are at least two distinct groups of sinuated shells with a band: one, containing *Hormotoma*, *Ectomaria*, etc., having the lines of growth sweeping back to and forward from the band very obliquely; and a second, containing *Lophospira*, having the lines less oblique and agreeing more in direction with those of *Murchisonia*, only the band is prominent instead of being grooved. A possible third group is indicated by a subgenus, subsequently described, in which the lines of growth are but slightly oblique and the band grooved. The first two groups in Britain range from Upper Cambrian to Silurian rocks, and the third from the Bala to the Silurian. The genus *Murchisonia* may have begun in the Wenlock formation. So far, no light is thrown on the question as to whether *Murchisonia* and *Pleurotomaria* were derived from the same stock, nor has the authoress yet met with any specimens showing a transition from sinus to slit.

In the latter part of the paper three new subgenera, eleven new species, and one new variety are described and figured.



Skeleton of the extinct 'Pigmy Hippopotamus' (*H. Madagascariensis*, Guldb.).

From Sirabé, Madagascar : now in the British Museum (Natural History), London. Obtained by Dr. C. I. Forsyth Major, F.Z.S.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. IX.

No. V.—MAY, 1902.

ORIGINAL ARTICLES.

I.—Some Account of a nearly complete Skeleton of *Hippopotamus Madagascariensis*, Guldb., from Sirabé, Madagascar, obtained in 1895.

By C. I. Forsyth Major, M.D., F.Z.S.

(PLATE XII.)

THE skeleton of a *Hippopotamus Madagascariensis*, Guldb., in the British Museum (Natural History) has been mounted from materials excavated by myself in the marshes of Sirabé (Central Madagascar) during the year 1895. The skull, lower jaw, several of the vertebræ, and presumably some other bones belong to the same individual.

My workmen reached a depth of five metres; the bones from which the skeleton is composed were found in the superficial deposit, but remains of *Hippopotamus*, apparently of a single species, are numerous at all depths.

We have a careful description of the skull and skeleton from the same locality by G. A. Guldberg,[1] and one by A. Grandidier & H. Filhol on materials collected by the former in the marshes of Ambolisatra on the south-west coast.[2] I myself have published some notes on the affinities of the Malagasy *Hippopotami* with the other then known species, living and extinct.[3]

There are in the British Museum (Natural History) rich collections from the interior and from the coast, which afford the materials for an exhaustive monograph of at least two of the three or four

[1] G. A. Guldberg, "Undersœgelser over en subfossil flodhest fra Madagascar": Christiania Videnskabsselskabs Forhandlinger, 1883, No. 6, pls. i and ii.

[2] Grandidier et H. Filhol, "Observations relatives aux ossements d'Hippopotames trouvés dans le marais d'Ambolisatra à Madagascar": Ann. Sci. Nat. Zoologie, ser. VII, vol. xvi (1893), pp. 151–190, pls. vii–xv.

[3] C. I. Forsyth Major, "On the general Results of a Zoological Expedition to Madagascar in 1894–96": Proc. Zool. Soc. London, 1896, pp. 976–978.

Malagasy species of the genus. As this work has still to be done, and as I do not care to give a compilation from the information already published, I wish the following lines to be considered merely as a brief explanatory note to accompany the figure of the mounted skeleton published in this number of the GEOLOGICAL MAGAZINE (Plate XII).

Remains of *Hippopotamus* from Madagascar, presumably from Sirabé, have been known for almost seventy years. In the Proceedings of the Geological Society of London[1] we find: "A letter was read from M. Telfair to Sir Alexander Johnstone, V.P.R.A.S., accompanying a specimen of recent conglomerate rock from the Island of Madagascar, containing fragments of a tusk and part of a molar tooth of a Hippopotamus, and communicated by Roderick Impey Murchison, Esq., F.G.S." These remains are preserved in the Museum of the Geological Society, the label accompanying stating them to come from a locality thirty miles from Antananarivo.

In 1867 M. A. Grandidier discovered remains on the south-west coast, to which in 1868 he assigned the name of *Hippopotamus Lemerlei*.[2]

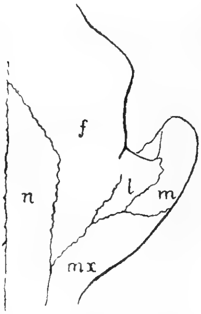


FIG. 1.—*Hippopotamus Sivalensis*, Falc. & Cautl. Frontal region; copied from fig. 3, pl. lix, Fauna Antiq. Sival.

f. frontal; *l.* lacrymal; *m.* malar; *mx.* maxillary; *n.* nasal bone.

Guldberg has compared the species from Sirabé with the living *H. amphibius* and *H. Liberiensis*, and comes to the conclusion that it occupies a somewhat intermediate position between the two, although approaching more closely to the former. I have formerly stated that all the Hippopotamus remains from Madagascar are certainly nearly related to each other, and this relationship may be briefly summed up as follows: In size they are intermediate between *H. Liberiensis* and *H. palæindicus*, with scanty indications of a larger form; in more important characters they would have to be placed, according to their greater or lesser degree of specialization, between *H. Sivalensis*

[1] Vol. i (1833), No. 31, p. 479.
[2] Comptes R. Ac. Sci. Paris, Dec. 14, 1868, vol. lxvii, p. 1165.

and *H. palæindicus* on one side and *H. amphibius* on the other; the lower end of the whole line being occupied by the most generalized form, *H. Liberiensis* of West Africa, the top by the most specialized, *H. major* of the Upper Pliocene of Europe.

The affinities thus expressed are based chiefly on the relative proportions of the cranial and facial parts of the skull, the former being greatly developed in *H. Liberiensis*, whereas in *H. amphibius* and in the *H. major* of the Upper Pliocene the cranial portion is much reduced, the facial portion on the contrary is enormously produced. The various crania from Madagascar have, in this respect, much resemblance to *H. Sivalensis*, the cranial portion, however, being somewhat shorter, the facial portion somewhat more elongate; so that the orbit occupies a less central position than in *H. Sivalensis* and, as a matter of course, still less so than in *H. Liberiensis*. "The Malagasy forms thus constitute a step farther in the direction of *H. amphibius*, the breadth of the intraorbital region being much less than in the African species and the same as in *H. Sivalensis*." [1]

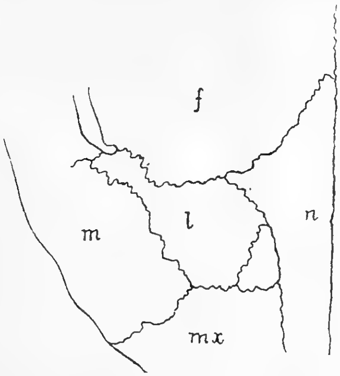


FIG. 2.—*Hippopotamus Madagascariensis*, Guldb. Frontal region of a skull from Sirabé, in the British Museum (Natural History).

f. frontal; *l.* lacrymal; *m.* malar; *mx.* maxillary; *n.* nasal bone.

These changes are reflected by the position of the lacrymal. In *H. Liberiensis* and *H. Sivalensis* (Text-fig. 1) the lacrymal is entirely separated from the nasal by the anterior prolongation of the frontal, which thus comes into contact with the maxillary; whereas in *H. amphibius* the lacrymal is usually broadly interposed between the frontal and maxillary.[2] I found long ago that the skulls from Sirabé exhibit in this respect also an intermediate position. As a rule, the lacrymal departs from the orbital margin in an inward direction and reaches the nasal, with which it broadly unites, thus shutting out the frontal from a connection with the maxillary.

[1] Op. cit., p. 977.

[2] See the exceptions in my paper, loc. cit., pp. 977, 978; and in Stehlin, Abhandl. Schweiz. Palaeont. Ges., vol. xxvii (1900), p. 434, footnote.

In front of the lacrymal, corresponding to the place which in *H. Liberiensis* and *H. Sivalensis* is occupied by the foremost tongue of the frontal, we find here a bone (Text-fig. 2) of varying dimensions, intercalated between the nasal and lacrymal, uniting with the maxillary in front, and sometimes reaching also the malar. In the skull of the figured skeleton the region under consideration presents the following conditions (Text-fig. 3). On the left side

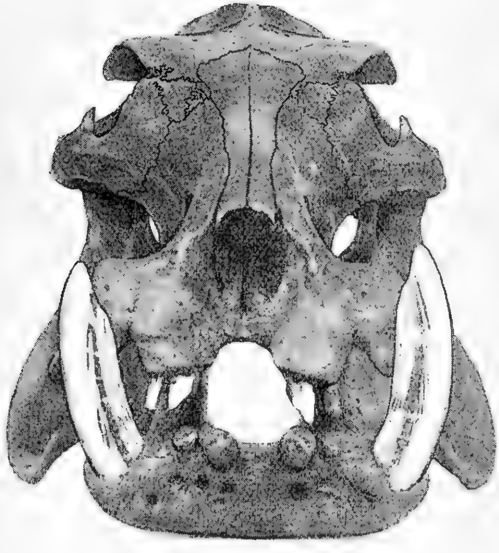


Fig. 3.—Front view of skull of *Hippopotamus Madagascariensis*, Guldb.

a short and narrow tongue of the frontal inserts itself between the lacrymal and nasal, where it meets with a similar but shorter prolongation of the maxillary. This is a stage slightly in advance of that figured by Falconer & Cautley in *H. palæindicus*[1]; in the latter the lacrymal is still very narrow, and the tongue of the frontal, though smaller than in *H. Sivalensis*, is still longer and broader than in the Malagasy skull. On the right side of the latter, two small supplementary bones are intercalated medially from the lacrymal; the posterior one is in contact with the frontal,

[1] Fauna Antiqua Sivalensis, pl. lvii, fig. 1.

nasal, lacrymal, and maxillary, the anterior with the lacrymal and maxillary, being separated from the posterior bone by a narrow prolongation of the lacrymal (see Text-fig. 3, right side).

During a visit to Paris several years ago, I pointed out to Professor Filhol the presence of a small intercalar bone between the nasal and lacrymal in one of the skulls from Ambolisatra; this has since been figured and discussed.[1] The bone being absent in the most generalized species of the genus, the name of prefrontal, which implies a homology with the so-called bone of lower vertebrates, appears to be unjustified; we have evidently to do in most cases with one (or more) Wormian bones. In some cases it may be simply an anterior prolongation of the frontal, the intermediate portion being covered by the expansion of the lacrymal.

Guldberg[2] has estimated the length of the *H. Madagascariensis* at 2·080 metres, assuming that the cranium is one-fifth of the length of the whole animal, as in *H. amphibius.* The mounted skeleton in the British Museum (Natural History) has a length of 1·95 metres.

I have elsewhere[3] stated that presumably "the Hippopotami entered Africa at a time when they were still in possession of all the characters of the Siwalik species, and that they crossed to Madagascar when they had reached a condition intermediate between *H. Sivalensis* and *H. amphibius.* In this condition they persisted in Madagascar, whilst on the neighbouring continent they progressed (or retrogressed) farther in the same direction." For reasons which I shall give farther on, we may assume to-day that Africa was the original home of the *Hippopotamus* tribe. But I see no reason to depart from the above statement as to their crossing over to Madagascar, presumably during the Pleistocene period. That the *Hippopotamus* persisted in the island up to a recent date, and was contemporary with man, may be assumed on the following grounds. Many of the remains are found in superficial deposits and present quite a fresh appearance. Grandidier & Filhol have figured[4] a femur from Ambolisatra, presenting two deep cuts evidently inflicted by man. At Sirabé the name of *Laliména* is given to the *Hippopotamus,* which my workmen recognized at once by the tusks, styled by them 'horns.' According to the legends of the inhabitants of the region, reported already by Dr. Borchgrevinck,[5] it was considered as the greatest exploit to fight the monster and deprive it of its 'horns.' This was termed to 'play' with the Laliména, and used to be the prerogative of the sons of the Betsileo kings.

It remains to add a few words on the presumed original home of the *Hippopotamus* tribe. Stehlin has pointed out in the skull of the chœromorid *Acotherulum,* from the Upper Eocene French Phosphorites, some features recalling decidedly the *Hippopotami*;

[1] Grandidier & Filhol, op. cit., p. 160, pl. viii.
[2] Op. cit., p. 24.
[3] Op. cit., p. 978.
[4] Op. cit., pl. xiv; see also p. 187.
[5] "Oversigt over Videnskabsselskabets Möder i 1882," pp. 8–11: Christiania Videnskabsselskabs Forhandlinger, 1882.

from this he argues that the latter may have been evolved from some member of the Chœromoridæ (very primitive pigs) nearly related to *Acotherulum.*[1] The later evolution of the *Hippopotami* must, however, have taken place outside Europe, since there is no trace whatever of ancestral *Hippopotami* in the Oligocene and the whole of the Miocene European deposits. The oldest known *Hippopotamus* is represented by scanty remains in the Lower Pliocene lignites of Casino (Italy); it was hexaprotodont like the Siwalik species, but more generalized than the latter in the shape of its molars.

Taking into further consideration the pigmy *Hippopotamus* (*Chœropsis*) *Liberiensis* from West Africa, a somewhat diverging lateral branch of the stem, which, according to Stehlin, has no relation with Asiatic and European fossil forms, he finally suggests that "possibly at the end of the Eocene, one of the Chœromoridæ, nearly related to *Acotherulum,* found a refuge in the Southern Continent [i.e. Africa], where during the Oligocene and Miocene periods it was gradually farther differentiated in the direction of the Hippopotamidæ."[2] This conclusion is very suggestive, especially when taken together with Andrews' recent discovery of the African origin of the Proboscidea. I wish to add that the Liberian *Hippopotamus has* affinity with the Lower Pliocene form of Europe, neither the one nor the other showing the specialized feature of a trefoil pattern so characteristic of the molars of *Hippopotamus* proper. Moreover, on account of the similarity of the lower canine and incisors of the Liberian '*Chœropsis*' with the same teeth of Cuvier's "*petit Hippopotame fossile*" (*H. minutus,* Blainv.), supposed to come from a locality in Southern France, Gervais has proposed for the latter the name *Chœropsis minutus.*[3]

This same species has of late been discovered in caves of Cyprus by Miss Dorothy M. A. Bate;[4] and for reasons stated in another place,[5] I have come to the conclusion that Cuvier's "*petit Hippopotame fossile*" was not found in France, but brought over from Cyprus. The *H. minutus* from Cyprus—which has little to do with the so-called '*H. minutus*' from Malta[6]—exhibits affinities with *H. Liberiensis,*

[1] Abhandl. Schweiz. Palaeont. Ges., 1900, pp. 433, 434.

[2] Op. cit., p. 488.

[3] Zool. et Pal. Gén., 1867–1869, i, p. 250.

[4] The ossiferous breccia at Chrysostomo, near Kythræa (Hagia Marina), in the district of Nicosia, which in Miss Bate's opinion must have originally been a cave, and from which she obtained the bulk of her collection, was, according to the account of the Dutch traveller Corneille le Brun (de Bruyn), well known in former times; the Greek inhabitants regarded and worshipped these *Hippopotamus* remains as the bones of their saints. (Corneille le Brun, "Voyage au Levant," etc., Delft, 1700, p. 375.) Le Brun figures (No. 193) a bone which he had worked out with great pains from the breccia, and says it resembles a human radius; but it can clearly be made out to be the femur of the *Hippopotamus,* represented from the posterior side and in two pieces, the larger fragment being the proximal, the smaller the distal portion.

[5] At the meeting of the Zool. Soc. of London, April 15th, 1902.

[6] For this Maltese species, which is intermediate in size between *H. Pentlandi* and *H. minutus,* and differs besides from the latter by exhibiting the characteristic trefoil pattern of the molars, I accordingly propose the new specific name of *Hippopotamus Melitensis.*

not only in its canines and incisors, but in its molars as well; they are of an even more generalized character and closely approach to those of the Casino form, though being of still smaller size.

In my opinion, therefore, this Pleistocene insular form is a slightly modified survivor of Tertiary Hippopotamidæ, as is also the recent *H. Liberiensis*—the latter, by the way, a parallel to that other early type, the *Ocapia*; the former points out the road, or one of the roads, by which the *Hippopotami* may have passed from Africa to more northern regions, before Cyprus was severed from its connection with the neighbouring continents. There are therefore good reasons for supposing that the Oligocene and Miocene ancestors of the *Hippopotami* had their home in Africa.

The assumption of a, geologically speaking, recent appearance of the *Hippopotami* in Madagascar is based on the more modernized characters of the Malagasy *Hippopotami*, as compared with the Pliocene members, with *H. minutus* and with *H. Liberiensis*, which characters place the first-named nearer to *H. amphibius*.

II.—On a Sodalite Syenite (Ditroite) from Ice River Valley, Canadian Rocky Mountains.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S.

In the year 1886 the late Dr. G. M. Dawson gave an account[1] of a syenitic rock, rich in a beautiful blue sodalite, which he had discovered when exploring the district near Hector Pass, on the watershed of the Canadian Rocky Mountains, and an analysis of the mineral was afterwards published by Professor Harrington.[2] The place was visited last Summer by Mr. E. Whymper during his examination of the district south of the Canada Pacific Railway, when he collected a number of specimens, which he showed to me on his return. The rock is hardly less beautiful than lapis lazuli, and as no description of its microscopic structure has been published, as far as I can ascertain, I give the results of my examination, together with a condensed account of its mode of occurrence. I am much indebted to Mr. Whymper for placing his specimens at my disposal, to Mr. L. Fletcher, Keeper of the Mineral Collection in the British Museum, for the opportunity of examining specimens of sodalite rock not in my own cabinet, and to Mr. L. J. Spencer, of that department, for giving me his kind assistance and valuable references to papers about the mineral.

Dr. Dawson states that the Beaver-foot Range, on approaching the Kicking Horse River,[3] becomes bordered by rounded and wooded hills, composed of slaty Cambrian rock, which, so far as can be

[1] "Physical and Geological Features of that portion of the Rocky Mountains between lat. 49° and 51° 30′": Geol. and Nat. Hist. Survey of Canada, 1885, p. 122, b.

[2] Trans. Roy. Soc. Canada, vol. iv, sect. iii, p. 81.

[3] Hector Pass, by which the Canada Pacific Railway crosses the watershed of the continent, was formerly called Kicking Horse Pass.

observed, underlie the valley, but that on the opposite side of this the centre of the high range is formed of an intrusive series of syenitic rocks, which he examined on Ice River, where they were well developed; and he continues (p. 122, B), "here the latter are first seen about two miles up the valley from the south-western base of the mountains at its entrance." Those on the east side of the valley are entirely composed of syenite, and further up those on the opposite one, as well as (apparently) those at its head; and the same mass is continued southward at least as far as the head of the Beaver-foot. It is newer than the slaty Cambrians, but posterior to their cleavage; this is lost as the rocks approach it, while they are baked and porcellanized. "The intrusive mass itself, though very varied in appearance in different places, is in the main a nepheline-syenite. The form most abundantly represented is a medium- to coarse-grained crystalline rock, composed of felspar, nepheline, and hornblende in varying quantities, with grains of magnetite and some crystals of sphene. The colour generally varies from pale grey to dark grey, becoming nearly black in places when the hornblende greatly preponderates. In such black varieties sphene is particularly abundant. The crystals of the component minerals are occasionally nearly an inch in length, while in rare instances they become almost cryptocrystalline. Other specimens derived from the same occurrence, but found as boulders in the bed of the torrent, have a banded and almost gneissic aspect, and under the microscope prove to contain numerous grains of quartz.[1] . . . . As far as I was able to determine, the mass appears to have been much disturbed, and as it were kneaded together while in a plastic or semi-plastic state. Portions of it have become brecciated and are recemented by similar material, differing only in texture or colour. Veins and crevices, which have evidently been filled by segregative action, also occur, and in these minerals similar to the main mass are developed; but with them, in considerable abundance, sodalite of a beautiful ultramarine-blue colour is found. In the same veins crystals of ilmenite were observed." After referring to Dr. Harrington's analysis of the sodalite (given below) he continues: "It much resembles lapis lazuli in appearance and would have considerable value as an ornamental stone. It is not confined to a single part of the intrusive mass, as it was found to occur in fragments brought down from the mountains further south in the bed of the Beaver Foot."

Mr. Whymper informs me that the Ice River Valley lies in the mountain mass to the south of the Canada Pacific Railway, where it descends in a south-western direction from the summit of Hector Pass to a place called Leanchoil. About three miles south of this the Kicking Horse River is joined by the Beaver-foot River, coming from the south-east, into which the Ice River has already emptied itself; this also follows a general south-west course, thus rising

[1] This mineral, as it happens, does not occur in the specimens which I have examined.

in the neighbourhood of the watershed of the Rockies. On its left bank the mountains (nepheline-syenite) form fine craggy peaks and a rocky cirque around its head. Their lower slopes are buried under débris, though here and there furrowed deeply by glens descending from the gaps between the peaks. In one of these, coming into the lower part of Ice River Valley, Mr. Whymper discovered the sodalite rock *in sitû* at the foot of a little crag, though even here it did not outcrop at the surface, but had to be exposed by digging away the débris, which prevented him from studying its relations with the nepheline-syenite. He also found loose pieces of the sodalite rock all the way to the head of Ice River Valley and in the principal lateral glens; so it must occur among the crags, no doubt in a vein-like fashion, in not a few places.

He brought away numerous specimens, though many of them were small in size. These are generally coarse-grained, sodalite and felspar being the dominant minerals. They also contain a little of a dull darkish-green mineral, an occasional small flake of brown mica, and a grain of pyrite. Nepheline may be among the felspar, but of that, so far as megascopic examination goes, I am doubtful. The sodalite is a rich blue, deeper in tint than ultramarine, occasionally almost a 'royal blue.'[1] The felspar is more or less cream-coloured. The structure of the rock is variable. Sometimes the sodalite is associated with the felspar, much as that mineral is with the quartz in a fairly coarse, almost binary granite. Sometimes the two are less uniformly distributed, so that the rock has a coarsely mottled look, and sometimes sodalite practically pure is streaked or veined by almost pure felspar, or *vice versâ*; the latter perhaps forming the more regular bands, which may be nearly an inch in breadth. But in a single fragment, a dozen square inches or so in area, the one type of rock may be seen to pass insensibly into the other. The specimens have led me to the conclusion that the rock originally consisted of a very irregular, often streaky mixture (such as may be seen in some 'pegmatite' veins) of felspar and sodalite or another mineral now represented by it, and that, though it shows some signs of fracture, it is not a brecciated mass of felspar cemented by sodalite.

Sodalite of a rich blue colour occurs associated with felspar at Dungannon and Faraday, in Hastings Co., Ontario. According to the description of Professors F. D. Adams and B. J. Harrington,[2] the country rock is a nepheline-syenite, which occasionally is extraordinarily coarse, for the crystals of nepheline[3] are said to be sometimes over two feet long, and the felspars of corresponding size, the latter, according to Professor Adams, being all plagioclase. The

[1] Mr. Whymper found a few specimens where the mineral was a pale blue.

[2] Amer. Journ. Sci., vol. xlviii (1894), pp. 10 and 16; see also vol. xlix (1895), p. 465.

[3] Professor Harrington thinks the term elæolite needless, for no line can be drawn between the specimens with the more oily and the more glassy lustre. So far as I have had the opportunity of judging, the distinction can hardly be maintained.

sodalite, of which Professor Harrington gives an analysis, occurs in streaks and irregular masses in the nepheline-syenite, the largest mass measuring about 10 × 10 × 4 inches. These are traversed by a few little veins of a white and reddish felspar, which on analysis is found to contain $K_2O = 12{\cdot}08$ and $Na_2O = 3{\cdot}67$, and thus to be a soda-orthoclase. Small scales of dark-brown to black mica occur in the sodalite. The constituents of the nepheline-syenite are plagioclase, nepheline, and either brown mica or dark-green hornblende; scapolite and calcite are accessories, seldom absent but never abundant, also sodalite, garnet, zircon, apatite, magnetite, and pyrite. Nepheline is the most abundant constituent; the plagioclase is albite, but with a small proportion of lime; the hornblende (probably rich in soda) shows fairly good crystalline outlines and characteristic cleavage; the calcite occurs like an original constituent, which is possible, as the rock is intrusive in limestone.

The specimen from Hastings in the British Museum is very like those brought by Mr. Whymper from the Ice River. A similar rock is found in boulders at Coburg on the north shore of Ontario. The same collection contains blue sodalite in a generally similar rock (with a vein of yellowish cancrinite) from Litchfield, Canada, as well as in the familiar Ditroite of Ditro (Transylvania) and Miascite from Miask in the Ilmen Mountains,[1] at Thorstrand, near Laurvig, and at Brevig, Norway, both of which have some resemblance to the Ice River specimen. The interesting variety from Lake Baikal[2] is massive, granular, and a rich dark-blue colour. A blue sodalite is found less abundantly in a rather compact brownish-grey rock at the Montreal Reservoir and at Heidelberg near the same city. Here it occurs in spots, which are often bordered by a white variety, and suggest filled up cavities. The mass of the rock is rather decomposed, but felspar and nepheline with the general structure of a phonolite can be recognized. Probably it would now be called a Tinguaite.[3]

Examination of slices cut from the Ice River Valley specimens shows the felspar to be imperfectly idiomorphic, with a slightly 'dusty' aspect, due to incipient decomposition. Most of it with crossed nicols exhibits a composite structure, with a minute acicular intergrowth or a colour mottling, the remainder having the twinning of plagioclase, though even here the components are rather more spicular in form and less sharply defined at the edges than is usual.[4] They evidently represent the peculiar group—perthite, soda-orthoclase, anorthoclase, and other plagioclases—so common in rocks exceptionally rich in soda, such, for instance, as are figured by Fouqué & Lévy[5] in the well-known rocks from Miask and Ditro and the elæolite-syenite from Brevig, except that I have not met

[1] As these rocks are practically identical, one of the names should be dropped.

[2] Described by Brögger and Backström: Zeitsch. Kryst., vol. xviii (1890), p. 222.

[3] For sodalite rocks in general see Rosenbusch, "Elemente der Gesteinlehre," 1898, pp. 115, 131. A most lucid description of the mineral sodalite is given by Fouqué & Lévy, Mineral. Micrograph., 1879, pp. 447–450.

[4] The extinction angles, measured from the composition edge, are rather small.

[5] Mineralogie Micrographique, pl. xlv, figs. 1 and 2.

with such a definite microcline as is represented in a slice from the Hungarian locality.

The sodalite occurs in irregular patches, sometimes of considerable size,[1] and in veins, these being sometimes very minute. It is generally water-clear and in very good condition, though occasionally it has a slightly dusty look or is traversed by a line of filmy microliths, giving bright tints with crossed nicols, probably due to incipient decomposition along minute cracks. In some parts the sodalite is a mass of small, tolerably well-formed hexagons (sections of dodecahedral crystals), ranging about ·003″ in diameter; in others they may be even ·2″ or ·3″ broad, but their outline then is less distinct; the first occasionally forming a kind of 'strait' in the second or filling little cracks in the felspars.

Pyroxene is represented by small patches, generally few in number, of a dull green, often muddy in aspect, tending, at any rate towards the ends, to become acicular or to form groups of little parallel prisms, an acicular microlith occasionally occurring; the clearer specimens show a faint pleochroism, the extinction angles are rather small, and the mineral is a rather light green by reflected light, so it is probably a soda-hornblende. It almost always occurs in association with the felspars. The specific gravity of a specimen with a little more pyroxene than usual is 2·58.

Zircon: two or three very minute enclosures may be this mineral. The occurrence of nepheline is doubtful, so is apatite, and iron-oxide is not present in the slices which I have examined.

Besides these specimens of sodalite syenite Mr. Whymper brought some fragments from other boulders in the Ice River Valley. One of these is a rather compact rock of a grey colour with a slight tinge of green, in which are scattered occasional elongated crystals of felspar, nearly ·3″ in length, and (more abundantly) similarly shaped dark hornblendes, the largest being about as long; both minerals, but especially the latter, lying more or less in parallel order. Under the microscope the rock is found to contain the following minerals:—(1) Felspars, in fair preservation; some apparently idiomorphic, others irregular in outline, the majority ranging from ·1″ to ·2″ in longer diameter, but occasionally about half-a-dozen granules less than ·01″ are associated between the larger grains; these mostly exhibit the peculiar mottled perthitic structure common in felspar-elæolite rocks, with a little plagioclase. (2) Nepheline, in characteristic and good preservation; sometimes in rather imperfect prisms, sometimes interstitial between the felspars, from which I conclude that the two minerals crystallized almost simultaneously. (3) Hornblende: the megascopic crystals already mentioned exhibit a moderately perfect crystalline outline, but are a little ragged at ends and edges; besides this they are locally fringed with independent granules of the same mineral. Both are pleochroic, the former changing from a rich brown to a very dark tint of the same, which towards the outside is occasionally tinged with green;

[1] I have a slice, practically all sodalite, about 1 inch long and rather less in breadth.

the latter sometimes showing only a change in a green tint, but occasionally passing from a fairly strong green to deep brown. I have not found an extinction angle exceeding 12°. The larger crystals include sphene, and once or twice a small grain of felspar. (4) Sodalite, not abundant or blue; in little interstitial patches of granules. (5) Sphene, rather abundant; obviously the first mineral to consolidate, for it is idiomorphic, and is included by or penetrates the hornblende. The specific gravity of this specimen is also 2·58.

Two small fragments "from boulders" are varieties (not quite so well preserved) of a similar rock, but are more gneissic in structure and contain, especially one of them, rather more dark pyroxene. Examination of thin slices shows three forms of this mineral: a slightly pleochroic (green to pale brown) augite, probably ægirine, a brown hornblende, and a green one (both as described above). The third seems formed from the second, but in one case also from a puce-brown augite (? titaniferous). A more normal orthoclase is common among the felspars, but microperthite and plagioclase are found. Nepheline is much less abundant than in the last specimen, but certainly occurs. There is a little sodalite, once or twice seeming to fill a crack, a grain or two of iron-oxide, some apatite, and a fair amount of sphene, these two being the first to form.

The fourth specimen has a dark-green groundmass, slightly mottled with a paler tint (which becomes yellowish-white on a weathered surface). In this are scattered grains, a little more than ·3″ in diameter, of a brownish-black pyroxene, with slight traces of a lustre-mottling. A slice proves the constituent minerals to be (1) a pleochroic augite, changing from a pale brownish-yellow to puce brown (probably a titaniferous variety), showing locally a diallagic habit by small dark parallel lines or rods, which when highly magnified appear a deep brown colour; a second set, making a large angle with these, being sometimes visible. (2) A green pyroxene in fair-sized grains, which, however, show a mottled or composite structure, probably a further stage of change. (3) A strongly pleochroic hornblende, changing from warm brown to deep brown. The relation of these pyroxenes is not easily determined. Sometimes a small grain of the augite seems to be included in the hornblende, sometimes the two lie side by side with a sharp line of demarcation, the crystals in each case having different orientations; but sometimes films or spots of the brown hornblende are connected either with augite of similar colour or with the green aggregate, as if formed from them. The brown augite is occasionally composite in structure, so I incline to regard these as a series of changes of which the brown hornblende is the last. (4) Iron-oxide: generally associated with the pyroxene, and later in consolidation, often enclosed in a very narrow, clear, composite border. (5) Apatite: very characteristic and rather abundant, generally containing some dusty material. (6) Nepheline, in irregular grains, acting as a sort of matrix to the pyroxene, containing sometimes minute colourless needles, and not seldom films similar to those already mentioned in connection with sodalite. (7) Felspar: doubtfully present, but may be represented by one small grain at the edge of the slice. (8) Sodalite: a little, very local in occurrence. It contains a few colourless belonites, and is associated with elæolite in a way strongly suggestive of a partial replacement of that mineral. (9) Sphene: two or three fair-sized grains, including apatite, and in one case pierced by a brown augite, may be either this mineral or (possibly) another variety of augite. Thus the rock, which has a specific gravity of 3·12, is more nearly related to the nepheline-dolerites than to the nepheline-syenites.

These specimens, especially the former, Mr. Whymper tells me may be taken to represent the country rock in which the masses rich in sodalite occur.

He also brought a flake-like specimen of fibrous actinolite and a fragment consisting of bits of a pale dull green chloritic or hornblendic rock, cemented with quartz, obviously from a vein.

One more specimen, though interesting in itself, has no direct bearing on the present investigation. It is a darkish grey rock of slightly foliated aspect, which on microscopic examination proves to consist of granular calcite and rather elongated prisms of tremolite (occasionally also in needles). Dusky patches of blackish granules occur in both minerals, but especially in the former, and very minute, rather filmy microliths are included in the latter. I do not remember to have seen a rock quite of this type before, but think it may be a result of contact-metamorphism.

What, then, is the history of the sodalite in the Ice River Valley rock? Is it an original constituent or of secondary origin? Sometimes it occurs in interstitial patches among the other minerals; sometimes it fills up cracks in the felspars. The first suggests an original constituent; the second must have formed after consolidation in fissures due to strain. But even in the former, sodalite may have replaced some other mineral, and in the latter obtained materials from it. Professor Harrington's analysis of the Ice River sodalite (rearranged by Dana in "System of Mineralogy," 1900) shows it to be remarkably pure:—

SiO_2	Al_2O_3	Na_2O	K_2O	Cl	
37·50	31·82	25·55	0·27	7·12	= 102·26

Typical analyses (see Dana) of this and two related minerals are:

	SiO_2	Al_2O_3	Na_2O	K_2O	Cl	Total.
Sodalite	37·2	31·6	25·6	—	7·3	101·7
Nepheline	44·0	33·2	15·1	7·7	—	100
Albite	68·7	19·5	11·8	—	—	100

If, for purposes of comparison, we reduce the Al_2O_3 (as the most stable constituent) to unity, we have:—

	SiO_2	Al_2O_3	Na_2O	K_2O
Sodalite	1·17	1	·80	—
Nepheline	1·32	1	·45	·23
Albite	3·52	1	·60	—

Thus, in forming sodalite like that of the Ice River from nepheline,[1] a certain amount of potash and of silica must be removed, and ·35 of soda added with the chlorine, an operation not difficult for heated water with a fair amount of sodium chloride in solution. To obtain it from albite, only ·20 of soda would have to be added with the chlorine, but 2·35 of silica, a rather large amount, must be removed. In the case of the Ice River rock (and not in this alone) I believe the larger patches of sodalite to have mainly replaced nepheline. At the same time I think it has, to some extent, also replaced a soda-felspar; small irregularly outlined bits of the latter, with a rather 'residual' aspect, are enclosed in the sodalite, especially near to its outside; the edge of the felspar also, where the two are in contact, seems to be a little corroded.[2] It is also evident, from its occurrence in the minute cracks, that some of the sodalite, especially that in the small dodecahedra, has been deposited from a state of solution. So I believe the sodalite to be a mineral of secondary origin in the principal cases mentioned in this paper, without, however, disputing that in some others it may be an original constituent.

III.—Notes on the Geology of Perim Island.[3]

By Catherine A. Raisin, D.Sc.

I AM indebted to Mr. J. A. Rupert Jones (Lieut. R.N.R.), now at Aden, for a series of rock specimens collected and sent from Perim Island, accompanied by notes and diagrams. From all these I have drawn up a short preliminary account, since they illustrate some points of interest, and no complete description of the geology of the island, as far as I know, has been published.

I. General Description.

Perim is a rocky barren island about 3 miles in length at the entrance to the Red Sea, bounded on the east by the "small strait," $1\frac{1}{2}$ miles broad, and on the west by the "larger strait," 9 to 10 miles across. It is roughly of a horse-shoe shape, surrounding a harbour opening to the south. Low plains below the 12 feet contour-line, evidently raised beaches, form much of the island (perhaps one-half or more), extending inland, especially at the north. The neighbouring sea is shallow, the 5 fathom contour-line bending into the harbour, the 10 fathom line extending outside the harbour to the south and around a large submarine plateau to the north. A narrow depression begins in the broader strait, and, after an interval, recommences further north and extends almost the whole length of the Red Sea, sometimes over 1,000 fathoms deep[4]—the whole resembling a submerged valley with abrupt sides.

[1] Fouqué & Lévy (loc. cit.) remark that the chemical formula of sodalite (allowing for the chlorine) is identical with that of nepheline. They and Rosenbusch (loc. cit.) allow that it may be a secondary mineral.

[2] Morozewicz made sodalite artificially by fusing kaolin or nepheline with soda and excess of sodium chloride; see Journ. Chem. Soc., vol. lxxvi, pt. 2 (1899), p. 764.

[3] An abstract of this paper was read at the British Association Meeting, Glasgow, 1901.

[4] The above depths are taken from the Admiralty Chart.

The islands in the Red Sea and the hills beyond the low coast plains are sometimes of sedimentary strata (e.g. Nubian Sandstone), sometimes of volcanic rock (as in Ketumbul, Jebel Teir). Other hills are of Archæan gneiss, while many islands are coral reefs or formed of coral, and calcareous sediment must be often deposited.[1]

Above the 12 feet contour-line, the island of Perim is hilly, rising to 249 feet at the highest point. The foundation rocks of the island are exposed in cliffs and quarries, and all the specimens sent are volcanic. The surface of the island, to a depth generally of about 7 feet, consists of irregular blocks, sometimes as much as 4 feet in diameter, imbedded usually in whitish calcareous sand or mud, and coral is common in the adjacent sea.[2] As described by Mr. Rupert Jones, the surface of the island has only to be rolled down when damp (the big blocks being removed) to set into a hard, smooth cycle track.

II. Petrological.

1. *Rocks in sitû:* (1) *Basalts.*—Two specimens from the cliff to north-east of Balfe Point, west of the island, were taken from two bands each about 12 feet thick. The rock is compact, dull brown, mottled with paler brown, splitting with a slabby or platy structure, which is more marked in the upper band. The lath-shaped microliths of plagioclase felspar exhibit a definite orientation, and are imbedded in a small amount of glassy base, with black granules and grains of iron oxide, small crystals of pyroxene, and a few rather larger crystals (usually pyroxene or felspar). Thus it is a not very basic magma basalt, approaching an andesite, and is probably a lava-flow.

In several of the Perim rocks two apparently ferro-magnesian minerals are found. One is augite, very pale greenish with low polarization tints; the other is in well-formed crystals, partly or wholly a reddish brown. The central part of these, when it is clear, shows rich polarization colours, has no cleavage, is rather granular, and sometimes contains enclosures. The mineral resembles olivine, but it might be a second pyroxenic constituent, and gradations from undoubted augite sometimes occur. In a few slides it constitutes microporphyritic crystals, but such crystals (few and small) more generally consist of felspar.

Another rock (from a cliff north-east of the harbour) is dull purplish red, mostly compact, rather coarser-grained than the last described, and without fluxional orientation. It contains one group of larger crystals, consisting of felspar (with glassy inclusions along crystal planes) and of augite.

(2) *Volcanic Tuffs.*—In a quarry east of Balfe Point (Fig. 1), some 25 feet deep, the basement rock, a layer about 1 foot thick, is whitish, mostly fine-grained, but with occasional fragments up to $\frac{1}{2}$ inch in diameter, weathers to a crumbling mass, but probably would set into a hard stone. Crystalline calcite, sometimes in

[1] At one spot, in the north of the Red Sea, a recent accumulation of oolitic grains was described by J. Walther, "Die Korallenriffe der Sinaihalbinsel," 1888.

[2] Marked on the Admiralty Chart.

definite rhombohedra, cements the grains and fills the vesicles. The material is chiefly pumice, but some fragments are a glass basalt. Broken crystals also occur of felspar, often plagioclase, of green hornblende, and brown-stained augite or olivine. One or two fragments exhibit perlitic cracks, and one, partly devitrified, has a radiating structure. Above this tuff occurs a fine material described as 'sand,' looser above, becoming harder below, but the character of an imbedded nodule suggests that the deposit is a fine volcanic dust.

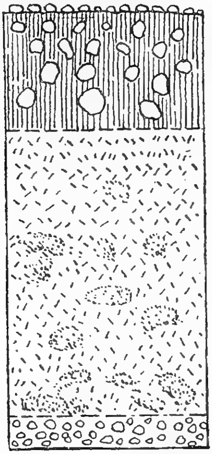


Fig. 1.—Section in a quarry east of Balfe Point.

A. Blocks of lava, described as imbedded in coarse calcareous sand.
B. Fine material resembling 'sand,' contains concretionary felsitic nodules, and is probably a fine trachytic ash.
C. White pumiceous tuff.

The nodule is roughly cylindrical, hard, pale brownish, and consists of felsitic fragments mostly sub-rotund, with a few angular chips of minerals like those in the underlying tuff. The pieces are crowded close together, cemented by an isotropic substance which is mammillated in form, and in the broader spaces passes to chalcedony; it is doubtless opaline silica. Thus originally fragments of the viscid lava were thrown down which solidified in cryptocrystalline condition, sometimes as a mere rim around a broken crystal; and a deposit of silica cemented the fragments.

2. *Surface Blocks.*—Specimens of these have been taken loose from many localities, and others from the two sections examined near the west of the island. In the section to north-east of Balfe Point calcite fills veins and cracks, few and sparse in the lava beds already described, but becoming abundant above, while the surface deposit to a depth of 7 feet consists of blocks imbedded in fine calcareous mud. These blocks are mostly a red or dark brown, ropy, scoriaceous basalt, but one is composed of fragments and is probably a brecciated lava. Two blocks sliced for the microscope

are almost identical with the lavas below, except that they are more vesicular. In the quarry above the pumiceous tuff (Fig. 1) one block from the surface deposit is a very similar blackish basalt full of rounded vesicles. Not far from this spot were two loose specimens, a pipy scoriaceous basalt, and a bright red fine-grained tuff containing thin streaks of black glass with small spherulites. The latter rock consists of microscopic yellow-rimmed pieces of brown glass, minutely vesicular, or partly devitrified, even slightly spherulitic, with broken crystals of green augite and of felspar.

Other surface blocks from north of the harbour and east of the island are basalts or allied rocks. (*a*) One block (projecting from a coral or limestone conglomerate) has, especially on a weathered surface, the granular appearance of a rock with incipient spherulites. The microscope slice, however, is uniform, except for small slightly paler patches.[1] It consists of abundant glass containing minute felspars, and is probably a rather basic andesite. (*b*) Two blocks from further north contain a few vesicles, are almost a microcrystalline basalt with very little glassy base, both semi-ophitic. (*c*) A block from north of the harbour resembles the red lava from the adjacent cliff, but is a brighter colour and more vesicular. Others near consist of a black basalt with a few vesicles. (*d*) Various blocks further east are generally blackish, often compact, and of similar character.[2]

Thus the specimens from surface blocks are almost all basaltic, often vesicular and scoriaceous. They show at each locality a general resemblance petrologically to lavas occurring there *in sitû*, where specimens of these have been obtained. Moreover, in the cliff section north-east of Balfe Point, we seem able to trace a gradual destruction of the underlying lavas through apparently brecciated layers to the surface deposit. Thus the surface blocks found generally over the island at different heights are probably more often disintegrated lava[3] than ejected fragments. In either case the blocks might have fallen into a sea where coral sand was accumulating, so that they would become imbedded in calcareous material. The low plains or raised beaches along the coast are frequently formed of a Recent limestone rich in large corals, Lamellibranchs, etc. I am indebted to Mr. Coomara Swamy for the loan of specimens from this rock, and also for a photograph representing the slope from which blocks of basalt, etc., might fall, to become imbedded in the limestone forming at the base. Even at higher levels, the calcareous material may sometimes represent sediment, often coral sand or mud, deposited during the gradual elevation of the island. The sea being shallow,

[1] I have found in other basalts or basic andesites (as in one from Auvergne) this appearance of incipient spherulites, which are not distinguishable on microscopic examination.

[2] Two slices lent me by Mr. Coomara Swamy, taken from blocks near here, are from very similar rock, but with the glassy base better defined and without the brown pyroxene.

[3] The disintegration of the rocks may have been helped by a rainfall greater in its amount in past times; and Mr. Jones remarks on the tanks built to hold water, now standing empty.

its waves and currents might exert some mechanical force.[1] Fine sediment would accumulate, and percolating water would deposit carbonate of lime. Secondary silica also occurs as in a flattened geode (about 3 inches long), lined with bluish mammillated chalcedony (resembling beekite), and in the opaline silica cementing the concretion in the section shown in Fig. 1.

III. Summary.

This district belongs to the extended volcanic area associated with the line of the Great Rift Valley. The abrupt descent of the bed in the Red Sea to a central channel may mark a part of that long depression, the form having been modified by later river action. The rocks of Perim probably correspond in age with the Aden basalts (the later volcanic period so named by Dr. Blanford), and they were doubtless emitted from some crater to the west of that at Aden. This ejected the material forming the pumiceous tuff of Perim, followed by the more abundant basaltic lavas. During depression and subsequent elevations of the land, the sea helped to carve out the straits of Babelmandeb and the gullies and rifts of the island. Coral reefs grew in the surrounding waters, and finally the raised beaches were formed, which record in Perim an uplift of at least 12 feet. The outline and depth of the harbour lend no support to the view that it marks an ancient crater, and the lavas and ashy beds which form the cliffs around it have generally a roughly horizontal direction. The indentation north-west of the harbour seems the end or continuation of a valley (containing the quarry of Fig. 1), extending from a raised beach here towards the raised beach near Balfe Point. Thus the present form of the land is mainly due to the usual forces of denudation and to oscillations of level, acting on an island built up of volcanic masses, within a shallow coral-bearing sea.

IV.—On the Correlation of the Palæozoic Rocks of South Africa.

By Walcot Gibson, B.Sc., F.G.S.

(*Continued from the April Number, p.* 165.)

The ancient rocks of Prieska are extensively developed in Griqualand West, where they build up the elevated Campbell Rand plateau and the lofty ranges of the Langebergen Mountains situated to the west of the Orange River Colony. The order of succession, which is much disguised by faulting and folding, has been described in great detail by Mr. G. W. Stow,[2] whose descriptions render it evident that the rocks of these regions resemble the older strata which extend over such vast areas in the Transvaal.

Several attempts have been made to classify the ancient rocks of the Transvaal, the results being nearly as numerous as the observers. In his latest classification of the rocks older than the Beaufort

[1] One example is described where the boulders appear as if piled by the sea, forming a kind of island in the middle of the Birkhud Raised Beach to the north of Perim.

[2] Q.J.G.S., vol. xxx (1874), pp. 581 680.

Beds, Dr. Molengraaff arranges them in the following descending groups:—

TABLE OF STRATA BELOW THE BEAUFORT BEDS OF THE TRANSVAAL.[1]

KARROO SYSTEM.	**Ecca Series**	Shales and diabases.
	Dwyka Conglomerate	A coarse conglomerate of variable composition and of glacial origin.
	Great Unconformity.	
	Amygdaloid Rocks of the Boschveld (age doubtful).	
CAPE SYSTEM.	**Waterberg Sandstones**... ...	Sandstones, breccias, conglomerates, diabases.
	Plutonic Series of the Boschveld	Porphyroids, red granites, norites.
	Pretoria Series	Shales, quartzites, diabases.
	Dolomite Series	Cherts and dolomites.
	Black Reef Series	Sandstones, quartzites, shales, and conglomerates.
	Great Unconformity.	
PRIMARY SOUTH AFRICAN SYSTEM.	**Amygdaloid Rocks**	Diabases, amygdaloidal lavas, porphyrites.
	Ancient Granite Series... ...	Grey granite.
	Barberton, Hospital Hill, and Witwatersrand Series ...	Schists, quartzites, gold-bearing conglomerates (Banket).

This table embodies the results obtained by Dr. Molengraaff during several excursions undertaken in the years 1898 and 1899 with the object of a future systematic study of the region, and is by far the most complete of any yet produced. Dr. Molengraaff's classification differs from nearly all others by including the Banket formation in the Primary South African System,[2] instead of considering it to be the northern equivalent of the Table Mountain Sandstone. Dr. Molengraaff further differs from many observers in regarding the granites and gneisses cropping out between Johannesburg and Pretoria and round Vredefort as intrusive into the Hospital Hill Series, whereas they have generally been considered to belong to a much older Archæan massif in which the gold-bearing rocks have been enfolded by earth-movements. Which view is correct can only be satisfactorily determined by systematic mapping. In the meantime it is of more service to draw attention to the results obtained in mining and especially from an examination of the area immediately round Johannesburg, of which considerable information has been obtained of late years.

Soon after the commencement of the gold industry the auriferous rocks were believed to be arranged in a unicline, comparable with an English coal-basin. In 1892 it was shown,[3] chiefly from observations from surface outcrops, that overthrusting had taken place to a considerable extent, possibly disguising the succession and certainly causing much repetition. Since then the progress of mining, and especially the development of 'Deep Levels,' has conclusively proved the existence of several overthrust faults of considerable vertical displacement, resulting in the duplication at the

[1] Dr. G. A. F. Molengraaff: Bull. Soc. Géol. France, 1901, ser. IV, t. 1.
[2] See also W. Gibson: GEOL. MAG., Dec. IV, Vol. IV (1897), pp. 548–550.
[3] W. Gibson: Q.J.G.S., vol. xlviii (1892), pp. 404–437.

surface of some of the reefs. The powerful effects of these overthrusts have been further demonstrated by the presence of shearing on the edges of the igneous dykes which are frequently situated along thrust planes; and also by the conversion, by dynamic action, of the smaller dykes into hornblendic and chloritic schists.[1] Minor movements are indicated by a conglomerate band known as the Main Reef Leader, being so firmly attached to the overlying quartzite that the reef is described as 'frozen' into it, while the footwall or underlay consists of a band of soft schist accompanied in many places by a vein of secondary quartz. These phenomena suggest a minor thrust plane coincident with the footwall. That this is so becomes more apparent in the Spes Bona Mine, where on the third level the conglomerate band known as the Main Reef is brecciated and is separated from the Main Reef Leader by eight feet of quartzite; while on the fourth level the two reefs are separated by a wedge-like mass, 40 feet wide, composed of a rock looking like a hard siliceous mudstone.[2]

Major thrusts have not been definitely proved underground, but there is little doubt that a dislocation of this nature separates the Hospital Hill Series from the Witwatersrand (Banket) Beds, as has been frequently described and figured since its existence was pointed out in 1892. Another major thrust of great intensity is indicated by the junction of the Hospital Hill Series with the granites and schists north of Johannesburg, where the two formations are so altered by dynamic action along their junction that all trace of a line of demarcation disappears (Molengraaff, op. cit., p. 20). The disposition of the quartzite ridges of the Hospital Hill Series north of Johannesburg and their progressive metamorphism as they approach this major thrust, taken in conjunction with their apparent great thickness, 8,000–10,000 feet,[3] strongly suggests that the various quartzite beds and intervening shales are due to duplication or even reduplication by overthrusting. Dr. Molengraaff denies the existence of anything more than a local duplication, though he acknowledges (op. cit., p. 22) that the "orogenic movements from south to north have been very energetic against the granite massif, which plays the part of a buttress."

Whatever may be the extent of the overthrusting, it is evident that the simple basin theory does not receive the support of recent investigation. The theory was mainly deduced from the generally observed decrease in the inclination of the reefs when followed in the direction of dip. It now appears that a secondary steepening of the dip has an extended occurrence along the Witwatersrand. This is most marked in the Simmer and Jack Mine, where from the 3rd to the 4th level the dip is 10° 40′, from the 6th to the 7th level 0° 30′, from the 10th to the 12th level 37°, and from the 14th to the 16th 29° 35′.[4] How vastly important to the future of the

[1] F. H. Hatch: Q.J.G.S., vol. liv (1898), p. 85.
[2] S. J. Truscott: "The Witwatersrand Goldfields; Banket and Mining Practice," 1898, p. 109.
[3] F. H. Hatch: op. cit., p. 79.
[4] S. J. Truscott: op. cit., p. 13.

gold-mining industry overthrusts will prove by counteracting the effects of this secondary steepening, is at once apparent.

In the group of rocks succeeding the Witwatersrand Beds Dr. Molengraaff finds a fancied resemblance to the sequence from the Table Mountain Sandstone and succeeding beds; the Black Reef Series, Dolomitic Series, and Pretoria Series being compared by him with the Table Mountain Sandstone, Bokkeveld Beds, and Witteberg Series. The dolomite in the Transvaal is unfossiliferous, while the Bokkeveld Beds contain a rich fauna of a Devonian facies. The dolomite most resembling that in the Transvaal is the rock in the Cango district, where, as previously stated, it is probably in an inferior position to the Table Mountain Sandstone. In Cape Colony the Witteberg Beds pass up conformably into the Dwyka Conglomerate; in the Transvaal the Glacial Conglomerate is markedly unconformable to the Pretoria Series. The resemblance, therefore, between the two colonies does not seem very exact. Regarding the unfossiliferous nature of the Transvaal older rocks, and the movements to which they have been subjected, it seems futile to attempt a correlation with the undetermined succession at the Cape; while to draw any comparison with the European Palæozoic rocks, as is frequently done, is *a fortiori* valueless deductive reasoning.

Of the older rocks of Rhodesia, Zululand, and Natal the information is scanty. It appears that the Bokkeveld Beds, or at any rate strata containing the Bokkeveld fossils, die out before they reach Natal, just as they do in the north-west provinces of Cape Colony. A fact in favour of their being unrepresented in the Transvaal.

To briefly summarize the knowledge of the older stratified formations in South Africa. The geological record is very imperfect. There are many rock groups, but excepting the Bokkeveld Beds at the Cape their age has not been determined. There are no certain representatives of strata of Silurian, Ordovician, and Cambrian ages. South Africa, then, appears to be the relic of an ancient massif composed of Archæan rocks, into which are sunk, in the form of complex anticlines and synclines, several rock groups of undetermined ages, which exist at the present day as lofty mountain ranges or as high plateaux, enclosing the western portion of the Indo-African basin in which the Karroo deposits were laid down.

Note.—A Graptolite, *Diplograptus pristis,* is stated to have been found in the slates of De Kaap, but this discovery has not been confirmed. (Trans. Geol. Soc. South Africa, 1896, vol. i, p. 52.)

V.—Some Trias Sections in South Staffordshire.

By Beeby Thompson, F.C.S., F.G.S.

An occasional visit to a village on the western border of South Staffordshire has given me the opportunity of studying the Triassic deposits around there. Possibly the various sections I have visited are well known to local geologists, although, so far, I have not come across any description of them. One section in particular, I think, must have been overlooked, and this it is now proposed to describe by way of an introduction to the more important remarks which follow from the pen of Dr. A. Smith Woodward.

A little over a mile to the south-east of Brewood, and a similar distance south-westward of Four Ashes Station on the Wolverhampton to Stafford line of railway, is a small section in the Keuper Sandstones and Marls. The opening is actually very near to Somerford Hall, but at the present time it is known as Chillington Brickyard.

When I first visited this section it was a stone quarry only; at the present time (1901), after having been idle for twelve years, it is being worked for brickmaking only. The possibility of this double use will be evident on reference to the description below.

Section at Chillington Brickyard (taken in 1887).

		ft.	in.
1.	Soil with pebbles	1	6
2.	Red marl	5	0
3.	Soft green marl	1	0
4.	Red marl	7	0
5.	Hard green marl	0	1
6.	Hard red marl	1	0
7.	Green sandstone with footprints	0	6
8.	Red sandstone with footprints	2	6
9.	Green sandstone with footprints	0	6
10.	"Best red" sandstone with footprints	7	0

Various layers of the beds 7 to 10 yielded large footprints of *Cheirotherium*. The casts of the impressions made are about ·25 m. and ·15 m. in length and breadth respectively, and the toes raised as much as 20 mm., indicating a comparatively large and heavy animal. Certain other layers were completely covered with casts of impressions of various kinds—worm tracks, worm castings, and small three-toed footprints. Of the five-toed footprints particularly referred to in Dr. Woodward's Notes, the examples I procured on one occasion were the only ones I ever saw at this quarry, although I have visited it four or five times.

No pseudomorphs of salt were discovered, but small flattish crystals of calcium sulphate occurred in some of the green stone (the workmen said pieces like glass), and this, in conjunction with numerous footprints, good ripple-marked and probably rain-pitted slabs at various horizons, suggests deposition of the material in a shallow lake with a fluctuating water-level.

Naturally the stone splits most easily where the footprints occur, the new sediment having been laid down upon a more or less consolidated older one.

It would appear that the Chillington section shows the junction of the Waterstones division of the Upper Keuper with the Red Marls of the same. There is no obvious unconformity, the conspicuous thin, green bands of both divisions being practically parallel.

At Great Chatwell, a few miles to the south-east of Newport (Salop), I found a very much coarser sandstone yielding footprints.

A large slab of stone, about 8 feet by 3 feet, placed beside a stile leading into the old disused quarry, had on it a number of small footprints. The two sections, Chillington and Chatwell, are about seven miles apart.

VI.—Notes on Footprints from the Keuper of South Staffordshire.

By A. Smith Woodward, LL.D., F.R.S., F.G.S.

THE footprints from the fissile Keuper sandstones of Chillington comprise, in addition to the ordinary Cheirotherian impressions, two interesting series. A number of fragments of rock covered with worm tracks and castings, show several imperfectly preserved footprints of a small five-toed animal, with posterior limbs of much greater size than the anterior; and three portions of comparatively smooth slabs afford evidence of a larger animal, probably of the same genus, of which the impressions of the feet are preserved with remarkable distinctness. There are also singular reticulated markings upon the surface of another small slab from the same beds, which may be interpreted as the impression of reptilian (?or labyrinthodont) skin. (See Fig. 2, p. 217.)

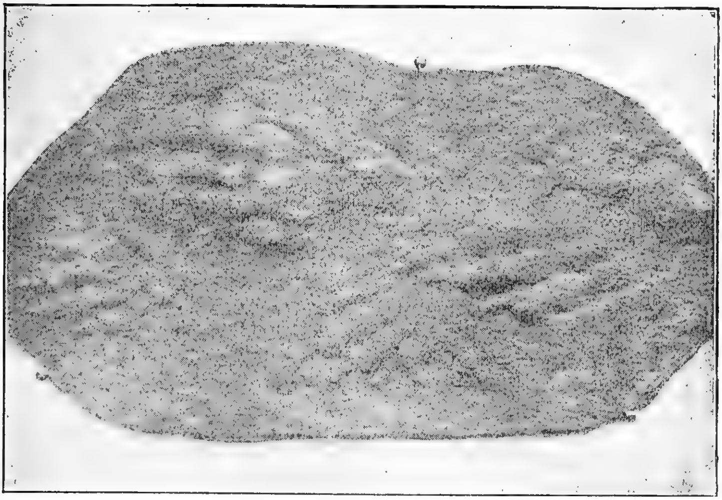


Fig. 1.—Footprints of *Rhynchosaurus* from the Keuper of South Staffordshire.

Of the specimens, the most noteworthy are the series of large five-toed footprints, and these admit of tolerably complete description. Like all the others, they are presented in the form of relief-counterparts of the original impressions. The largest slab (No. I), measuring 0·18 m. by 0·09 m., shows two prints both of the hind- and fore-foot (left side), following in natural succession; a smaller slab (No. II) exhibits one impression of each foot, partly obscured by a film of matrix; and a third fragment (No. III) shows an imperfect hinder footprint.

In No. I (Fig. 1) the total length of the fore-foot is 0·04 m., and the maximum breadth 0·025 m. As in the hind-foot, the terminal phalanges are very distinctly shown to have the form of sharp claws, and the fifth digit is slightly opposed to the remainder. The joints of digits I to III are well seen, and comprise respectively 2, 3, and 4 phalanges; but Nos. IV and V are unfortunately indistinct. The hind-foot is relatively more elongated than the fore-foot, and measures approximately 0·07 m. in length by 0·038 m. in maximum breadth. The first four toes successively increase in size outwards, but the fifth is very small—perhaps, indeed, the smallest. The number of phalanges is 2, 3, and 4 in digits I to III respectively; and specimen No. II shows clearly that there are 5 in digit IV. The 'palm' of the foot, so to speak, is of considerable length, and in the hind-foot much narrowed posteriorly.

Less distinct footprints of this character have already been ascribed by Sir Richard Owen to *Rhynchosaurus*,[1] and later writers have adopted this interpretation when referring to other similar specimens.[2] It was not until 1887, however, that it became possible to institute a careful comparison of the marks with the actual feet of the genus just mentioned. In that year Professor Huxley described[3] a skeleton of *Rhynchosaurus* in the British Museum, which comprises the broken remains of both fore- and hind-feet, agreeing precisely in relative proportions with the Chillington footprints, and almost identical with these in absolute size. So far as can be determined in the fossil, the number of phalanges in the respective digits is quite lacertilian, and the small dimensions of the fifth digit in the footprints is also suggestive of the latter conforming to the same type. Moreover, *Rhynchosaurus* must have been an animal of sprawling gait, such as would leave the footprints first described by Murchison and Strickland (loc. cit.); and the present specimens, though not in long series, are sufficient to show that a similar form of animal impressed them. The footprints are thus very distinct in character from those of *Cheirotherium*, in which the feet of the right and left sides are seen to have trodden successively almost in a single straight line.

The impression of a web between the toes, noted by Murchison and Strickland in the slab in the Warwick Museum, is not clearly shown in the new specimens; but in some of the smaller footprints appearances are suggestive of its original presence.

[1] R. Owen, "Description of an Extinct Lacertian Reptile, *Rhynchosaurus articeps*, Owen": Trans. Cambridge Phil. Soc., vol. vii (1842), p. 355. Sir Richard Owen refers to the specimens described by O. Ward—"On Footprints and Ripple Marks of the New Red Sandstone of Grinshill Hill, Shropshire," Brit. Assoc. Rep., 1839, Trans. Sect., p. 75; also by Murchison and Strickland, Trans. Geol. Soc. [2], vol. v, p. 339, pl. xxviii, fig. 1, from the Keuper of Shrewley, Warwickshire.

[2] E.g., R. Harkness, "Footprints from Bunter Sandstone, Weston Point, near Runcorn, Cheshire": Ann. Mag. Nat. Hist. [2], vol. vi (1850), pp. 207, 441.

[3] T. H. Huxley: Quart. Journ. Geol. Soc., vol. xliii (1887), pp. 689–692, pl. xxvii.

The slab No. IV (Fig. 2), with impressions apparently of skin, is about six inches square, and the reticulated markings extend over two ill-defined but separate areas. One of these patches is convex and very suggestive of being a portion of the counterpart of a footprint, but there are no marked boundaries. The small polygonal raised areas enclosed by the reticulate markings vary in size in different parts from 0·0015 m. in diameter to 0·004 m. At one side of the slab is an indistinct portion of a small footprint resembling *Rhynchosaurus*.

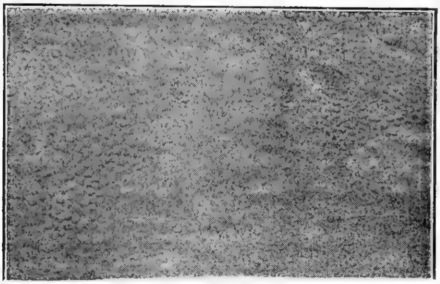


Fig. 2.—Skin impression: footprint of *Cheirotherium* (?).

On comparing this fossil with known specimens, its resemblance to the skin-impression in a Cheirotherian footprint described by Professor Williamson[1] is seen to be very striking. There is also a sun-cracked slab in the British Museum (No. R. 295) from the Trias of Lymm, Cheshire, upon which a number of small Rhynchocephalian footprints are associated with scattered indistinct reticulate markings and enclosed raised areas of a somewhat similar character.

Footprints and impressions are under all circumstances most unsatisfactory fossils to interpret, but it now seems quite certain that Sir Richard Owen's determination of those of *Rhynchosaurus* is correct. It may be convenient to add, in conclusion, that an elaborate synopsis of all that is known regarding such fossils, with full references, was published by Dr. T. C. Winkler in 1886.[2] Later valuable contributions to the same subject have been made by Herr Pabst[3] and Mr. Beasley.[4]

[1] W. C. Williamson, "On a Cheirotherian Footprint from the Base of the Keuper Sandstone of Daresbury, Cheshire": Quart. Journ. Geol. Soc., vol. xxiii (1867), pp. 56–7, pl. iii.

[2] T. C. Winkler, "Histoire de l'Ichnologie": Archiv. Mus. Teyler [2], vol. ii, pt. 4 (1886).

[3] W. Pabst, "Thierfährten aus dem Oberrothliegenden von Tambach in Thüringen": Zeitschr. deutsch. geol. Ges., vol. xlviii (1896), pp. 638–643, pl. xiv; and vol. xlix (1897), pp. 701–712, pls. xxv–xxviii.

[4] H. C. Beasley, "An Attempt to classify the Footprints in the New Red Sandstone of this District": Proc. Liverpool Geol. Soc., vol. vii (1896), pp. 391–409, pls. i–iii. "Notes on Examples of Footprints, etc., from the Trias in some Provincial Museums": loc. cit., vol. viii (1898), pp. 233–237, pl. xi.

VII.—The Cambrian Age of the *Dictyonema* Slates of New Canaan and Kentville, Nova Scotia.

By H. M. Ami, M.A., D.Sc., F.G.S., of the Geological Survey of Canada.

In his "Acadian Geology" (1868, 2nd ed., p. 563) Sir William Dawson figures *Dictyonema Websteri* and places it as a Silurian (Upper Silurian) species. In describing the slates from which the type-specimens of this species were obtained he writes:—"Passing from the Cobequid Mountains to the slate hills of the south side of the Bay" (meaning the Bay of Fundy), "in King's County, we find slates not very dissimilar from those of the Cobequids" (which he had described on the previous page, 562), "in the promontory northward of the Gaspereau River. Here the direction both of the bedding and of the slate structure is N.E. and S.W.; but the planes of cleavage dip to the S.E., while the bedding, as indicated by lines of different colour, dips to the N.W. These slates, with the quartzite and coarse limestones, are continued in the hills of New Canaan, where they contain crinoidal joints, fossil shells, corals, and in some beds of fawn-coloured slate beautiful fan-like expansions of the pretty *Dictyonema*, represented in fig. 196; very fine specimens of this fossil were found by the late Dr. Webster of Kentville. It was the habitation of thousands of minute polypes, similar apparently to those of the modern *Sertularia*. The general strike of the rocks in New Canaan is N.E. and S.W., and they extend from that place westward to the Nictaux River. Westward of Nictaux River, as already mentioned in describing the Devonian, the beds of the Upper Silurian, as well as those of the last-mentioned formation, are interrupted by great masses of granite which form the hills along the south side of the Annapolis River, from a place called Paradise to Bridgetown, and with some interruptions nearly as far as the town of Annapolis."

In my "Synopsis of the Geology of Canada,"[1] the following paragraph refers to the Silurian of the region in question as presented and systematized from available information:—"In the County of Annapolis, Nova Scotia, and in the vicinity of Nictaux, Silurian strata occur, including the *Nictaux* iron-ore beds and the *Torbrook* sandstone formation, whilst near Kentville the Kentville formation is seen as well as on Angus Brook in the Gaspereau valley, also at New Canaan with *Dictyonema Websteri*, Dawson." Slates holding *Dictyonema Websteri*, Dawson, are thus known to occur (1) at New Canaan, N.S., the type locality (2) at Kentville, N.S.; and (3) on the north slope of the South Mountain, along the upper portion of the valley of Angus Brook, a small stream entering the Gaspereau River between the village of Gaspereau and the Avon River shore.

Heretofore, the slates which have yielded the specimens of *Dictyonema Websteri* have been invariably referred to the Silurian system, but more recent examination of the type-specimens of

[1] Trans. Roy. Soc. Canada, 1900–1901, ser. II, vol. vi, sect. 4, p. 203.

D. Websteri have revealed remarkable and indubitable resemblance and close affinity of this species with the *Dictyonema flabelliforme*, Eichwald, which finds a synonym in the *D. sociale* of Salter, a characteristic Upper Cambrian form.

In comparing the microscopical characters of the rhabdosome of *D. Websteri* with those of *D. flabelliforme*, Eichwald, especially as they are presented and illustrated in Carl Wiman's classic work,[1] the peculiar rope-like structure of the polypary is clearly discernible, so that there is practically no doubt as to the identity of the two species.

It will therefore now be necessary to refer *D. Websteri* as a synonym of *D. flabelliforme*, Eichwald, and to refer the Kentville formation, not to the Silurian (Upper) system, but to the Cambrian. In fact, the slates of the Kentville formation of Kings and Annapolis Counties in Nova Scotia are equivalent in age or are taxonomically similar to the slates of Barachois and associated localities in the Nura Series of Cape Breton, as well as to the *Dictyonema* slates of Navy Island, near St. John City, and the slates of Eel River, near Benton in New Brunswick, all of which are referable to the Upper Cambrian.

The first *rapprochement* made by me between *Dictyonema flabelliforme* and *D. Websteri* took place some two years ago, when the specimens of *Dictyonema* obtained by Professor L. W. Bailey near Benton, along the Eel River in York Co., N.B., were compared with the specimens of *D. Websteri* at present in the collections of the Geological Survey Department, and they were found to be so closely related as not to be practically separable. From specimens of *D. flabelliforme* obtained on Navy Island, kindly loaned to me for study and reference by Professor Bailey of the University of New Brunswick, it was readily seen that the Benton specimens were identical and therefore of Upper Cambrian age.

In order to ascertain definitely whether *D. Websteri*, Dawson, from New Canaan, was identical with *D. flabelliforme*, the type-specimens of the former, which formed part of the Dawson collections in the Peter Redpath Museum of McGill University, were kindly loaned to the writer by Professor F. D. Adams. These are preserved on two slabs of more or less hardened red shale or slate, and scattered over the surface of the slates in a rather poor state of preservation, except in one case from which very probably the illustration (fig. 196) on p. 563 of the "Acadian Geology" was prepared.

The writer is satisfied that the upper beds of the Cambrian are thus represented in that portion of Nova Scotia by the *Dictyonema flabelliforme* beds at Kentville, New Canaan, and the Gaspereau Valley, south side.

We thus find that the zone or horizon of *Dictyonema flabelliforme*, Eichwald, occurs at the following localities in Canada, which may consequently be referred to the Upper or Neo-Cambrian :—

[1] See "Ueber die Graptoliten": Bull. Geol. Inst. Upsala, p. 55, pl. x, figs. 13, 14. Also Eichwald, "*Gorgonia flabelliformis*": Sil. Schicht. Syst. in Esthland, 1840, p. 207.

(1) Matanne, Quebec, south shore of St. Lawrence River.
(2) Cape Rosier, Gaspé, Quebec, near Lighthouse.
(3) Barachois, Cape Breton, Nova Scotia.
(4) Navy Island, near St. John, New Brunswick.
(5) Shales near Benton, York County, above Fredericton, New Brunswick.
(6) New Canaan, Annapolis County, Nova Scotia.
(7) Kentville, Annapolis County, Nova Scotia.
(8) Angus Brook, Gaspereau Valley, Kings County, Nova Scotia.

VIII.—A List of the 'Type,' Figured, and Described Fossils in the Norwich Castle Museum.

By Frank Leney, Assistant-Curator of Norwich Museum.

(*Concluded from p.* 171.)

Elephas meridionalis, Nesti. Portion of right lower m. 3. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 11, 11*a*, and "Pal. Memoirs" (1868), vol. i, p. 446; vol. ii, p. 136. Leith Adams, ibid., p. 196. Forest Bed (?): Hasbro' Oyster Bed. S. Woodward Coll. 5 [1771].

—— Portion of right lower molar. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 8, 8*a*, and "Pal. Memoirs" (1868), vol. i, p. 445; vol. ii, p. 136. Leith Adams, ibid., p. 192. Forest Bed: Norfolk coast. Old Coll. 18 [1770].

—— Right lower m. 3. Leith Adams, ibid., p. 196. Forest Bed: Bacton. Gurney Coll. 12 [1775].

—— Left lower m. 3. Leith Adams, ibid., p. 197. Forest Bed (?): Bacton. Gurney Coll. 23, 24 [1692, 1704].

—— Left lower m. 3. Leith Adams, ibid., p. 197. Forest Bed: Mundesley cliffs. Gunn Coll. 222 [1712].

—— Portion of left lower m. 3. "Memorials of John Gunn" (1891), p. 68. Norwich Crag: Horstead, Norwich. Gunn Coll. 224 [1573].

—— Left lower m. 3. Leith Adams, ibid., p. 198. Dredged off Norfolk coast. Gunn Coll. 329 [1735].

—— Left lower m. 3. Leith Adams, ibid., p. 197. Forest Bed: Mundesley. Gunn Coll. 317 [1759].

—— Portion of right lower molar. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 9, 9*a*, and "Pal. Memoirs" (1868), vol. i, p. 446; vol. ii, p. 136. Leith Adams, ibid., p. 193. Forest Bed (?): Norfolk coast. S. Woodward Coll. 4 [1783].

—— Right lower molar. "Memorials of John Gunn" (1891), p. 69. Norwich Crag: Horstead, Norwich. Gunn Coll. 305 [1581].

—— Left lower molar. "Memorials of John Gunn" (1891), p. 69. Norwich Crag: Coltishall, Norwich. Gunn Coll. 333 [1576].

—— Portion of lower m. 3. Falconer, "Fauna Ant. Siv." (1846), pl. xiv B, figs. 12, 12*a*, and "Pal. Memoirs" (1868), vol. i, p. 446; vol. ii, p. 136. Leith Adams, ibid., p. 193. Forest Bed: Mundesley. Old Coll. 3 [1778].

Elephas meridionalis, Nesti. Portion of lower molar. Leith Adams, ibid., p. 198. "Memorials of John Gunn" (1891), pl. i (Probos.), pp. 8, 71, fig. E. Forest Bed (?): Hasbro' Oyster Bed. Gunn Coll. 221 [1762].

—— Portion of molar. "Memorials of John Gunn" (1891), p. 69. Norwich Crag: Horstead, Norwich. Gunn Coll. 331 [1583].

—— Left half of pelvis. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 143. Forest Bed: Mundesley cliffs. Gunn Coll. 226 [1611].

—— Left half of pelvis. Falconer, "Pal. Memoirs" (1868), vol. ii, pp. 141–143. Leith Adams, ibid., pp. 150, 151. "Memorials of John Gunn" (1891), pp. 73, 74. Forest Bed: Mundesley. Gunn Coll. 225 [1615].

—— Portion of scapula. Leith Adams, ibid., p. 213, pl. xviii, fig. 3. Dredged off Yarmouth. Gunn Coll. 275 [1618].

—— Left humerus. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 143. Leith Adams, ibid., p. 215, pl. xvi, fig. 2. "Memorials of John Gunn" (1891), p. 73. Forest Bed: Mundesley. Gunn Coll. 200 [1620].

—— Left humerus. Owen, "Brit. Foss. Mammals" (1846), p. 251 (*E. primigenius*). Falconer, "Pal. Memoirs" (1868), vol. ii, p. 143. "Memorials of John Gunn" (1891), pp. 70, 73. Forest Bed: Bacton. Gurney Coll. [1622].

—— Distal end of humerus. Leith Adams, ibid., p. 215, pl. xvi, fig. 3 (Forest Bed *errore*). [? Norwich Crag]: Rockland, Norwich. Mr. J. Hobrough [1619].

—— Radius. Leith Adams, ibid., p. 217. "Memorials of John Gunn" (1891), pp. 74, 75. Forest Bed: Mundesley. Colman Coll. [1621].

—— Right femur. Leith Adams, ibid., pp. 164, 222. "Memorials of John Gunn" (1891), p. 74. Forest Bed: Mundesley. Colman Coll. [1599].

—— Shaft of right femur. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 144. Leith Adams, ibid., p. 224 (No. 288 *errore*). "Memorials of John Gunn" (1891), p. 49. Forest Bed: Walcot, near Bacton. Gunn Coll. 228 [1601].

—— Shaft of femur. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 144. Forest Bed: Norfolk coast. Gunn Coll. 230 [1592].

—— Head of femur. Leith Adams, ibid., p. 224. Forest Bed: Mundesley. Gunn Coll. 237 [1613].

—— Distal end of femur. Leith Adams, ibid., p. 224, pl. xxii, fig. 5 [No. 236 *errore*]. Forest Bed: Bacton. Gunn Coll. 23 [1596].

—— Distal end of femur. Leith Adams, ibid., p. 223. Forest Bed: Palling. Colman Coll. [1606].

—— Left tibia. Leith Adams, ibid., p. 225. Forest Bed: Bacton. Gunn Coll. 241, 242 [1588, 1591].

Elephas meridionalis, Nesti. Fibula. Leith Adams, ibid., p. 226. Dredged off Yarmouth. Gunn Coll. 256 [1953].

—— Distal and proximal ends of fibula. Leith Adams, ibid., p. 226. Forest Bed: Bacton. Gunn Coll. 240 [1607].

—— Distal end of tibia. Leith Adams, ibid., p. 225. Forest Bed: Norfolk coast. Gunn Coll. 243, 247 [1623, 1635].

—— Cuneiforme. Leith Adams, ibid., p. 219. Forest Bed: Norfolk coast. Gunn Coll. 156, 159 [1667, 1671].

—— Internal cuneiforme. Leith Adams, ibid., p. 228, pl. xxi, fig. 2. Forest Bed: Norfolk coast. Gunn Coll. 188 [1954].

—— Unciforme. Leith Adams, ibid., p. 220. Forest Bed: Norfolk coast. Gunn Coll. 172 [1672].

—— Scaphoid. Leith Adams, ibid., p. 159. Forest Bed: Norfolk coast. Gunn Coll. 150 [1660].

—— Lunare. Leith Adams, ibid., p. 159. Forest Bed: Mundesley. Gunn Coll. 151 [1663].

—— Magnum. Leith Adams, ibid., p. 220. Forest Bed (?): Norfolk coast. Gunn Coll. 164 [1658].

—— Trapezoidale. Leith Adams, ibid., p. 220. Dredged off Yarmouth. Gunn Coll. 160 [1661].

—— Metatarsus 3. Leith Adams, ibid., p. 229. Forest Bed: Mundesley. Fitch Coll. [1648].

—— Metatarsus 5. Leith Adams, ibid., p. 329. Forest Bed: Norfolk coast. Gunn Coll. 195 [1645].

—— vide *E. antiquus*, Falc. [1788].

—— vide *Mastodon latidens*, S. Woodw. [1567].

Elephas primigenius, Blum. Incisor tooth. Leith Adams, ibid., p. 187. Submarine deposits near Lowestoft. Colman Coll. [1870].

—— Lower jaw. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 174. "Memorials of John Gunn" (1891), pp. 71, 74, 78, pl. iv (Probos.), fig. 3. Dredged off Margate, Kent. Gunn Coll. 360 [1846].

—— 1st dorsal vertebra. Leith Adams, ibid., p. 149, pl. xvii, fig. 7. Dredged off Lowestoft, Suffolk. Colman Coll. [1931].

—— Left scapula. Leith Adams, ibid., p. 213, pl. xxii, fig. 4. Dredged off Yarmouth. Gunn Coll. 271 [1947].

—— Abnormal right femur. Leith Adams, ibid., p. 167. Dredged off Yarmouth. Gunn Coll. 255 [1912].

—— Lunare. Leith Adams, ibid., p. 159. Dredged off Yarmouth. Gunn Coll. 155 [1651].

—— Molar tooth with glacial markings. "Memorials of John Gunn" (1891), pl. ii (Probos.), fig. K. H. B. Woodward, Proc. Geol. Soc., Aug. 1893, vol. xlix, p. 146. "Reconstructed Chalk": Witton, near Bacton. Gunn Coll. 359 [1949].

—— vide *E. meridionalis*, Nesti [1622].

—— Prototype; vide *E. meridionalis*, Nesti [1696].

Elephas primigenius, Blum. Prototype; vide *E. antiquus,* Falc. [1847].

Elephas (*Loxodon*) *priscus,* Goldfuss. Portion of lower jaw with m. 2. Falconer, Quart. Journ. Geol. Soc., vol. xxi (1865), p. 272, and "Pal. Memoirs" (1868), vol. ii, p. 99, pl. vii, figs. 3, 4. Leith Adams, ibid., p. 23 (*E. antiquus*). Forest Bed: Palling beach. Gunn Coll. 307 [1832].

Elephas sp. Portion of lower molar. "Memorials of John Gunn" (1891), pl. i (Probos.), fig. I (*E. giganteus intermedius,* Gunn MS.). Forest Bed (?): Mundesley. Gunn Coll. H. [1765].

—— Incisor tooth. "Memorials of John Gunn" (1891), p. 79, pl. v (Probos.), fig. 3. Forest Bed (?): Norfolk coast. Rose Coll. N. [1793].

Equus caballus-fossilis, Rütimeyer. Left up. m. 1 and 2. E. T. Newton, "Vert. Forest Bed" (1882), pl. vii, figs. 6, 7. Forest Bed: Cromer. Gunn Coll. [423, 424].

Eucladoceros, Falc.; vide *Cervus Sedgwickii,* Falc. [243].

Gazella anglica, E. T. Newton. Horn-core. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 23. Norwich Crag: Horstead, Norwich. Colman Coll. [1000].

Gulo luscus, Linn. Portion of left ramus of lower jaw. E. T. Newton, Geol. Mag. [2], vol. vii (1880), p. 424; "Vert. Forest Bed" (1882), p. 17, pl. vi, figs. 1, 1*a*. Forest Bed: Mundesley. Fitch Coll. [392].

Hippopotamus major, Owen. Right ramus of lower jaw. Owen, "Brit. Foss. Mamm." (1846), pp. 399, 409, figs. 159, 162. Forest Bed: Cromer. Gurney Coll. [394]. *Type.*

—— Tusk. Owen, ibid., p. 410. Forest Bed (?): Cromer beach. Gurney Coll. [414].

Lutra Reevei, E. T. Newton. Germ carnassial tooth. E. T. Newton, Quart. Journ. Geol. Soc., vol. xlvi (1890), p. 446; "Vert. Pliocene Deposits" (1891), p. 13, pl. i, fig. 13. Norwich Crag: Bramerton, Norwich. Reeve Coll. [548]. *Type.*

Machærodus (?). Carnassial tooth. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 6, pl. i, fig. 2. Norwich Crag: Thorpe, Norwich. Fitch Coll. [549].

Mastodon angustidens, Kaup. Portion of lower tusk. Owen, "Brit. Foss. Mamm." (1846), pp. 291, 295, fig. 101. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 43 (*M. arvernensis,* C. & J.). Fluvio-marine Crag: Norwich. Fitch Coll. [1543].

—— Left upper m.m. 3. Owen, "Brit. Foss. Mamm." (1846), p. 284, fig. 100. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 36 (*M. arvernensis,* C. & J.). Fluvio-marine Crag: Postwick, Norwich. Fitch Coll. [1552].

—— Lower m. 2. Owen, "Brit. Foss. Mamm." (1846), p. 281, fig. 99. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 33 (*M. arvernensis,* C. & J.). Fluvio-marine Crag: near Norwich. Fitch Coll. [1547].

Mastodon angustidens, Kaup.; vide *M. latidens*, S. Woodw. [1567].

Mastodon arvernensis, C. & J. Right upper molar. "Memorials of John Gunn" (1891), p. 67, pl. i (Probos.), fig. A. Norwich Crag: Horstead, Norwich. Gunn Coll. G. [1540].

—— vide *M. angustidens*, Kaup. [1543, 1547, 1552].

Mastodon latidens, S. Woodw. Portion of molar tooth. S. Woodward, Mag. Nat. Hist., vol. ix (1836), p. 154, figs. 23*a*, *b*. Owen, "Brit. Foss. Mamm." (1846), p. 289 (*M. angustidens*, C. & J.). Falconer, "Pal. Memoirs" (1868), vol. ii, p. 131 (*Elephas meridionalis*, Nesti). [Norwich Crag]: Bramerton, Norwich. S. Woodward Coll. [1567].

Monodon monoceros, Linn. Portion of tusk. H. B. Woodward, "Geology of Norwich" (1881), p. 96. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 79. Brickearth: Sprowston, Norwich. Mr. G. Bacon [525].

Ovibos moschatus, Zimm. Skull. Boyd Dawkins, Quart. Journ. Geol. Soc., vol. xxxix (1883), p. 575, woodcut. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 22. Forest Bed: Trimmingham. Rev. F. Buxton [487].

Ovis aries, Linn. Metatarsal. "Memorials of John Gunn" (1891), p. 58, pl. ii (Probos.), figs. *a*, *b*. Recent deposit: Happisburgh. Gunn Coll. I [9].

Phoca sp. Right humerus. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 19, pl. ii, fig. 1. Norwich Crag: Bramerton, Norwich. Crowfoot and Dowson Coll. [380].

Rangifer tarandus (Linn.); vide *Cervus tarandus*, Linn. [70].

Rhinoceros etruscus, Falc.; vide *R. tichorinus*, Fischer [460].

Rhinoceros leptorhinus, Owen. Upper molar tooth. Owen, "Brit. Foss. Mamm." (1846), p. 381. Forest Bed: near Cromer. Fitch Coll. [448].

Rhinoceros leptorhinus, Owen; vide *R. megarhinus*, Christol [446].

Rhinoceros megarhinus, Christol. Right upper p.m. 4. Boyd Dawkins, Quart. Journ. Geol. Soc., vol. xxiii (1867), p. 214. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 398 (*R. leptorhinus*, Owen). E. T. Newton, "Vert. Forest Bed" (1882), p. 40, pl. ix, fig. 1. Forest Bed: near Cromer. Gunn Coll. [446].

Rhinoceros tichorhinus, Fischer. Left ramus of lower jaw. Owen, "Brit. Foss. Mamm." (1846), p. 347. Falconer, "Pal. Memoirs" (1868), pp. 347, 355 (*R. etruscus*, Falc.). E. T. Newton, "Vert. Forest Bed" (1882), p. 39, pl. viii, fig. 7. Forest Bed: Cromer. Fitch Coll. [460].

Strongyloceros, Falconer; vide *Cervus verticornis*, Dawk. [305].

Talpa europæa, Linn. Right and left lower jaws. E. T. Newton, "Vert. Forest Bed" (1882), p. 95, pl. xv, figs. 1, 2. Forest Bed: Bacton. Gurney Coll. [523].

Trichechus Huxleyi (?), Lank. Proximal half of right femur. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 18, pl. ii, fig. 3. Chillesford Beds: Aldeby, Suffolk. Crowfoot and Dowson Coll. [393].

Trogontherium Cuvieri, Cuvier. Right ramus of lower jaw. E. T. Newton, "Vert. Forest Bed" (1882), pl. xi, fig. 9. Forest Bed: Mundesley. Fitch Coll. [381].

—— Left ramus of lower jaw. Owen, Geol. Mag., vol. vi (1869), p. 52, fig. 4. E. T. Newton, "Vert. Forest Bed" (1882), p. 69, pl. xi, fig. 11. Forest Bed: Mundesley. Fitch Coll. [382].

—— Left ramus of lower jaw. E. T. Newton, "Vert. Forest Bed" (1882), p. 69, pl. xi, fig. 7. Forest Bed: Bacton. Gurney Coll. [383].

—— Left femur. Owen, Geol. Mag., vol. vi (1869), p. 49, pl. iii, figs. 1–4. E. T. Newton, "Vert. Forest Bed" (1882), p. 74, pl. xi, fig. 18. Forest Bed: Mundesley. Gunn Coll. [387].

—— Left calcaneum. Owen, Geol. Mag., vol. vi (1869), p. 49, pl. iii, fig. 8. E. T. Newton, "Vert. Forest Bed" (1882), p. 74, pl. xi, fig. 20. Forest Bed: Mundesley. Gunn Coll. [386].

Ursus spelæus, Blum. Left ramus of lower jaw. Falconer, "Pal. Memoirs" (1868), vol. ii, p. 466 (*Ursus* sp.). E. T. Newton, "Vert. Forest Bed" (1882), p. 7, pl. i, fig. 2; pl. iii, fig. 2. Forest Bed: Cromer. Gurney Coll. [375].

—— Portion of left ramus of lower jaw. E. T. Newton, "Vert. Forest Bed" (1882), p. 10, pl. iii, fig. 3. Forest Bed: Norfolk coast. Old Coll. [371].

—— Canine tooth. E. T. Newton, "Vert. Forest Bed" (1882), p. 11, pl. ii, fig. 8. Forest Bed (?): Norfolk coast. Gunn Coll. [378].

—— Distal end of left humerus. E. T. Newton, "Vert. Forest Bed" (1882), p. 14, pl. ii, fig. 4. Forest Bed: Happisburgh. Gunn Coll. 380 [374].

Rodent ? genus. Cheek tooth. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 54, pl. v, fig. 19. Norwich Crag: Bramerton, Norwich. Reeve Coll. [544].

Small Ruminant. Outer incisor tooth. E. T. Newton, "Vert. Pliocene Deposits" (1891), pl. iii, fig. 10. Norwich Crag: Thorpe, Norwich. Fitch Coll. [550].

AVES.

Grus communis, Bechs. Tibiæ and radius. A. Newton, Trans. Norf. and Nor. Nat. Soc., vol. vii (1901), p. 158. Peat [Estuarine Deposit]: King's Lynn. Gunn Coll. [1978].

Uria troile, Linn. Shaft of humerus. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 84, pl. ix, fig. 5. Chillesford Crag: Aldeby, Suffolk. Crowfoot and Dowson Coll. [547].

REPTILIA.

Chelonia harviciensis, S. Woodward. S. Woodward, "Synoptical Table" (1830), p. 44, frontispiece. London Clay: Harwich Harbour. Rev. J. H. Bloom [1517]. *Type.*

Emys lutaria, Schneider. Carapace. E. T. Newton, Geol. Mag. [2], vol. vi (1879), p. 304, pl. viii. H. B. Woodward, Trans. Norf. and Nor. Nat. Soc., vol. iii (1880), p. 36. Clement Reid, "Geology of Cromer" (1882), p. 119. "River Bed": Mundesley. John Gurney, Esq. [160].

Leiodon anceps, Owen. Vertebræ. T. G. Bayfield, Geol. Mag., vol. i (1864), p. 296. Upper Chalk: Lollard's Pit, Norwich. T. G. Bayfield, Esq. [1983].

PISCES.

Gadus morrhua, Linn. Otolith. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 93, pl. x, fig. 5. Norwich Crag: Bramerton, Norwich. Reeve Coll. [546].

Gadus pollachius, Linn. Portion of otolith. E. T. Newton, "Vert. Pliocene Deposits" (1891), p. 96, pl. x, fig. 15. Norwich Crag: Bramerton, Norwich. Reeve Coll. [545].

CRUSTACEA.

Pollicipes Angelini, Darwin. Scutum and tergum. C. Darwin, "Fossil Lepadidæ" (Pal. Soc., 1851), p. 56, tab. iii, fig. 7. Upper Chalk: Norwich. Fitch Coll. [2152]. *Types.*

Pollicipes fallax, Darwin. Scutum and tergum. C. Darwin, ibid., p. 75, tab. iv, fig. 8. Upper Chalk: Norwich. Fitch Coll. [2153]. *Types.*

Pollicipes striatus, Darwin. Carina, tergum, and scutum. C. Darwin, ibid., p. 71, tab. iv, fig. 5. Upper Chalk: Norwich. Fitch Coll. [2154]. *Types.*

Scalpellum fossula, Darwin. Associated plates. C. Darwin, ibid., p. 24, tab. i, fig. 4. Upper Chalk: Norwich. Fitch Coll. [2136]. *Type.*

Scalpellum maximum, J. Sow., var. *typicum*, Darwin. Scutum. C. Darwin, ibid., p. 28, tab. ii, fig. 8. Upper Chalk: Norwich. Fitch Coll. [2139].

—— —— Carina. C. Darwin, ibid., p. 28. Upper Chalk: Norwich. Fitch Coll. [2138].

—— —— var. i. Tergum. C. Darwin, ibid., p. 30, tab. ii, fig. 5. Upper Chalk: Norwich. Fitch Coll. [2141].

—— —— var. ii. Scutum. C. Darwin, ibid., p. 29, tab. ii, fig. 9. Upper Chalk: Norwich. Fitch Coll. [2147].

—— —— var. ii. Tergum. C. Darwin, ibid., p. 30, tab. ii, fig. 6. Upper Chalk: Norwich. Fitch Coll. [2145].

—— —— var. iii. Tergum. C. Darwin, ibid., p. 31, tab. ii, fig. 7. Upper Chalk: Norwich. Fitch Coll. [2142].

ANNELIDA.

Vermicularia (?). S. Woodward, "Geology of Norfolk" (1833), p. 49, tab. vi, fig. 18. Upper Chalk: Norwich. S. Woodward Coll. [2230].

Vermilia macropus, J. Sow. S. Woodward, ibid., tab. v, fig. 18. Upper Chalk: Norwich. S. Woodward Coll. [3330].

ECHINODERMATA.

***Ananchytes** Bayfieldi,* S. P. Woodward MS. H. B. Woodward, "Geology of Norwich" (1881), p. 27. Flint Gravel: Norwich. S. Woodward Coll. [2232].

***Asterias** lunatus,* S. Woodward. S. Woodward, "Geology of Norfolk" (1833), tab. v, fig. 1. "Hard Chalk": West Norfolk. S. Woodward Coll. [3307]. *Type.*

***Ophiura** Fitchii,* Forbes MS. H. B. Woodward, "Geology of Norwich" (1881), p. 27. Flint Gravel: Norwich. Fitch Coll. [2294].

***Spatangus** excentricus,* Rose. S. Woodward, "Geology of Norfolk" (1833), p. 57, pl. i, fig. 5. Flint Gravel: near Norwich. S. Woodward Coll. [3308].

GASTEROPODA.

***Buccinum** Dalei,* J. Sow. S. V. Wood, "Crag Moll.," Suppl. (1872), p. 16. Fluvio-marine Crag: Postwick, Norwich. Reeve Coll. [829].

***Cassis** avellana,* Brong. S. Woodward, "Geology of Norfolk" (1833), tab. vi, fig. 22. Upper Chalk: Norwich. S. Woodward Coll. [2107].

***Cerithium** derivatum,* S. V. Wood. S. V. Wood, "Crag Moll.," 2nd Suppl. (1879), p. 39, woodcut. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [754]. *Type.*

***Cerithium** Greenii* (?), Adams. S. V. Wood, ibid., p. 23, tab. iv, fig. 16 (*Sandbergeria Reevei,* S. V. Wood MS.). Chillesford Beds: Bramerton, Norwich. Reeve Coll. [755].

***Cerithium** unicarinatum,* S. Woodw. S. Woodward, "Geology of Norfolk" (1833), tab. vi, fig. 21. Upper Chalk: Harford Bridge, Norwich. S. Woodward Coll. [2106]. *Type.*

***Chemnitzia** internodula* (?), S. V. Wood, var. *ligata,* S. V. Wood. S. V. Wood, "Crag Moll.," 2nd Suppl. (1879), p. 24, tab. ii, fig. 11. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [570].

***Hydrobia** obtusa,* Sandb. S. V. Wood, ibid., p. 30, tab. iv, fig. 7. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [756].

***Limnæa** auricularia,* Linn. S. V. Wood, ibid., p. 36, tab. iv, fig. 3*a*. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [757].

***Limnæa** palustris,* Müll. S. V. Wood, ibid., p. 37, tab. iv, fig. 2. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [584*a*].

***Margarita** argentata* (?), Gould. S. V. Wood, "Crag Moll.," Suppl. (1872), p. 84, tab. v, fig. 12. Chillesford Beds: Aldeby, Suffolk. Crowfoot and Dowson Coll. [896].

***Odostomia** (?) derivata,* S. V. Wood. S. V. Wood, "Crag Moll.," 2nd Suppl. (1879), p. 40, woodcut. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [758].

Odostomia Reevei, S. V. Wood. S. V. Wood, "Crag Moll.," 3rd Suppl. (1882), p. 9, tab. i, fig. 12. Fluvio-marine Crag: Bramerton, Norfolk. Reeve Coll. [762]. *Type.*

Odostomia sp. S. V. Wood, "Crag Moll.," 2nd Suppl. (1879), p. 40. Fluvio-marine Crag: Bramerton, Norfolk. Reeve Coll. [759].

Paludestrina Reevei, A. S. K. & B. B. W. A. S. Kennard & B. B. Woodward, Proc. Malac. Soc., vol. iii (1899), p. 198, woodcut. Norwich Crag: Blake's Pit, Bramerton. Reeve Coll. [767]. *Type.*

Pupa edentula, Drap. S. V. Wood, "Crag Moll.," 2nd Suppl. (1879), p. 37, tab. iv, fig. 6. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [760].

Purpura lapillus, Linn. S. V. Wood, ibid., p. 5, tab. i, fig. 13. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [616*a*].

Rissoa proxima, Alder. S. V. Wood, ibid., p. 40. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [761].

Sandbergeria Reevei, S. V. Wood MS.; vide *Cerithium Greenii*, Adams [755].

Scalaria Trevelyana, Leach. S. V. Wood, "Crag Moll.," Suppl. (1872), p. 58, tab. iv, fig. 6. Chillesford Beds: Aldeby, Suffolk. Crowfoot and Dowson Coll. [905].

Trophon antiquus, Linn., var. *carinatus contrarius*, S. V. Wood. S. V. Wood, "Crag Moll.," Suppl. (1872), p. 19, tab. i, fig. 10*a*. Fluvio-marine Crag: Bramerton (?), Norwich. Captain Alexander [849].

LAMELLIBRANCHIATA.

Cultellus pellucidus (?), Penn. S. V. Wood, "Crag Moll.," Suppl. (1874), p. 148, tab. x, fig. 14. Chillesford Beds: Aldeby, Suffolk. Crowfoot and Dowson Coll. [928].

Inoceramus latus, Mant. S. Woodward, "Geology of Norfolk" (1833), tab. i, fig. 7. Flint Gravel: Norwich. S. Woodward Coll. [2229].

Lasæa intermedia, S. V. Wood. S. V. Wood, "Crag Moll.," Suppl. (1874), p. 123, tab. x, fig. 22*b*. Chillesford Beds: Aldeby, Suffolk. Crowfoot and Dowson Coll. [932]. *Type.* [Probably the figured specimen, S. V. W. MS.]

Lucina borealis, Linn. S. V. Wood, ibid., p. 128, tab. ix, fig. 5. Chillesford Beds: Aldeby, Suffolk. Crowfoot and Dowson Coll. [937].

Lucinopsis undata, Penn. S. V. Wood, ibid., p. 129, tab. ix, fig. 4. Chillesford Beds: Aldeby, Suffolk. Crowfoot and Dowson Coll. [938].

Ostrea alæformis, S. Woodw. S. Woodward, "Geology of Norfolk" (1883), p. 48, tab. vi, fig. 3. Upper Chalk: Norwich. S. Woodward Coll. [2100]. *Type.*

Ostrea triangularis, S. Woodw. S. Woodward, ibid., tab. vi, fig. 7. Upper Chalk: Harford Bridge, Norwich. S. Woodward Coll. [2099]. *Type.*

Pecten princeps, J. Sow., var. ***pseudo-princeps***, S. V. Wood. S. V. Wood, "Crag Moll.," Suppl. (1874), p. 103, tab. viii, fig. 9*b*. Fluvio-marine Crag: Bramerton, Norwich. Captain Alexander [873].

Pinna sulcata, S. Woodw. S. Woodward, "Geology of Norfolk" (1833), tab. v, fig. 23. Upper Chalk: St. Giles' Gate, Norwich. S. Woodward Coll. [2111].

Siliquaria parva, Speyer. S. V. Wood, "Crag Moll.," 2nd Suppl. (1879), p. 40; 3rd Suppl. (1882), p. 11, tab. i, figs. 16*a*, *b*. Fluvio-marine Crag: Bramerton, Norwich. Reeve Coll. [763].

Spondylus Dutempleanus, D'Orb. H. Woods, "Cret. Lamell." (Pal. Soc., 1901), pl. xxiii, figs. 3, 5. Upper Chalk: Norwich. Fitch Coll. [2113, 2114].

BRACHIOPODA.

Crania striata, Rose. S. Woodward, "Geology of Norfolk" (1833), p. 48, tab. vi, fig. 15. Upper Chalk: Harford Bridge, Norwich. S. Woodward Coll. [2231].

Kingena lima (Defr.). Davidson, "Cret. Brachiopoda" (Pal. Soc., 1852), p. 45, pl. iv, figs. 17, 19. Chalk: Letheringsett. Rose Coll. [3219].

—— Davidson, ibid., p. 45, pl. iv, fig. 20. Upper Chalk: Norwich. Fitch Coll. [2060].

Magas pumilus, Sow. Davidson, ibid., p. 24, pl. ii, figs. 7, 8. Chalk: Letheringsett. Rose Coll. [3218].

Rhynchonella limbata (Schl.). Davidson, ibid., p. 80, pl. xii, figs. 1, 2, 3 [fig. 3 not found]. Upper Chalk: Norwich. Fitch Coll. [2065].

Rhynchonella plicatilis, Sow., var. ***octoplicata***, Sow. Davidson, ibid., p. 78, pl. x, figs. 1–11 [= 8 specimens]. Upper Chalk: Norwich. Fitch Coll. [2068].

Rhynchonella plicatilis, Sow., var. ***Woodwardii***, Dav. Davidson, ibid., p. 79, pl. x, figs. 43, 44. Upper Chalk: Norwich. Fitch Coll. [2069].

Terebratula biplicata (Brocchi), var. ***Dutempleana***, D'Orb. Davidson, ibid., p. 57, pl. vi, figs. 1, 2. Red Chalk: Hunstanton. Fitch Coll. [2830].

Terebratula capillata, D'Archiac. Davidson, ibid., p. 46, pl. v, fig. 12. Red Chalk: Hunstanton. Fitch Coll. [2833].

Terebratula carnea, Sow., var. ***elongata***, Sow. Davidson, ibid., p. 70, pl. viii, fig. 3. Upper Chalk: Norwich. Fitch Coll. [2072].

Terebratula obesa, Sow. Davidson, ibid., p. 54, pl. v, figs, 13, 14. Upper Chalk: Norwich. Fitch Coll. [2074, 2075].

Terebratulina gracilis (Schl.). Davidson, ibid., p. 40, pl. ii, fig. 14. Upper Chalk: Norwich. Fitch Coll. [2081].

Terebratulina striata (Wahl.). Davidson, ibid., p. 38, pl. ii, fig. 18. Upper Chalk: Norwich. Fitch Coll. [2080].

Trigonosemus elegans, Koenig. Davidson, ibid., p. 30, pl. iv, figs. 1, 2. Upper Chalk: Norwich. Fitch Coll. [2079].

POLYZOA.

Flustra foliacea (?), S. Woodw. S. Woodward, "Geology of Norfolk" (1883), tab. i, fig. 4. Flint Gravel: Norwich. S. Woodward [2228]. *Type.*

SPONGIDA.

Ventriculites infundibuliformis, S. Woodw. S. Woodward, "Geology of Norfolk" (1833), tab. iv, fig. 21. Upper Chalk: Norwich. S. Woodward Coll. [2222]. *Type.*

The following specimens have not been found:—

Mastodon angustidens, Kaup. Molar tooth, figured by Owen, "Brit. Foss. Mamm." (1846), p. 283, fig. 98.

Rhynchonella limbata (Schl.), figured by Davidson, "Cret. Brachiopoda" (Pal. Soc., 1852), pl. xii, fig. 3.

Assiminea Grayana (?), Leach, figured by S. V. Wood, "Crag Moll.," 2nd Suppl. (1879), tab. iii, fig. 18.

I am much indebted to Mr. James Reeve, F.G.S., Curator of the Norwich Castle Museum, without whose long and intimate knowledge of the collection this list could not have been satisfactorily completed. My thanks are also due to Dr. A. Smith Woodward, F.R.S., of the British Museum (Nat. Hist.), for his kind encouragement.

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COLLECTIONS.

Colman Collection.—A collection of mammalian remains from the "Forest Bed" deposits of Norfolk and Suffolk, formed by the late J. J. Colman, Esq., M.P. Presented by Russell J. Colman, Esq., 1898.

Crowfoot and Dowson Collection.—A small collection representative of the fauna of the Norwich Crag at Aldeby, Suffolk. A list is published in the Proceedings of the Norwich Geological Society, vol. i (1878–9), pp. 24, 81. Presented by Messrs. W. M. Crowfoot, M.B., and E. T. Dowson, 1868.

Fitch Collection.—A general collection of fossils, mostly of local origin, including a very fine series from the Chalk of Norwich, and mammalian remains from the "Forest Bed." Presented by the late Robert Fitch, Esq., F.S.A., F.G.S., 1893.

Gunn Collection.—A large series of mammalian remains from the "Forest Bed" deposits of the Norfolk coast. For a history and description of this collection see "Memorials of John Gunn" (1891). Presented by the Rev. John Gunn, M.A., F.G.S., 1868.

Gurney Collection.—This collection was formed early in the last century by Miss Anna Gurney, of Northrepps Cottage, Cromer, and contains some rare examples of mammalian remains from the "Forest Bed" of Cromer. Presented 1845.

Johnson Collection.—A collection formed by Randall Johnson, Esq., of Waxham. It includes some perfect limb-bones of Elephants from the "Forest Bed." It was acquired by J. J. Colman, Esq., and incorporated in his collection. (See Trans. Norf. and Nor. Nat. Soc., vol. ii, 1877, p. 279.)

Reeve Collection.—A representative series of the molluscan fauna of the Norwich Crag at Bramerton, near Norwich. This collection, the result of thirty years' work, is referred to in nearly every work on the Crag deposits, and a list is published in the Proceedings of the Norwich Geological Society, vol. i (1879–81), pp. 69, 110. Collected and presented by James Reeve, Esq., F.G.S., Curator of Norwich Museum.

S. Woodward Collection.—A general collection formed by Samuel Woodward, Esq., author of "Geology of Norfolk" (1833), etc. The collection of fossils does not appear to have been received in its entirety, as it is impossible to trace more than a few of the specimens figured in the above work. Purchased by subscription, 1839. (See Trans. Norf. and Nor. Nat. Soc., vol. ii, 1879, p. 588.)

The *Norwich Museum* was founded in 1824, and taken over by the Corporation of the city in 1894. For an account of its origin and progress see Guide Book by Thomas Southwell, Esq., F.Z.S., Norwich, 1896.

REVIEWS.

I.—The Scenery of England and the Causes to which it is due. By the Right Hon. Lord Avebury (Sir John Lubbock, Bart.), F.R.S., D.C.L., LL.D., F.G.S., etc. Royal 8vo; pp. 534, with 197 illustrations. (London: Macmillan & Co., Ltd., 1902. Price 15*s*. nett.)

(PLATES XIII and XIV.)

THE name of Lubbock is one to conjure with, and has for so many years arrested public attention, and become "familiar in their mouths as household words," that it is no easy matter to abandon the memory of it, or to recognize our esteemed and valued friend under his new guise, however high be the dignity which the title confers.

In his capacity as a popular writer it may be truly said of the author *Nihil quod tetigit sed ornavit*, and certainly the field of his discourses has been wide indeed. From 1865, when he wrote on Prehistoric Times; Primitive Man; and the Origin of Civilization; to the Use and the Pleasures of Life, and the Beauties of Nature; of Flowers, Fruit, and Leaves; of British Wild Flowers; of Insects; Ants, Bees, and Wasps; and many other "Chapters in Popular Natural History"; we pass on to the "Scenery of Switzerland," and now to that of England itself.

In the writings of the early fathers we find the surface of the primitive earth described as, originally, perfectly smooth, but after the wickedness of mankind had brought upon it the Noachian Deluge the fountains of the great deep were broken up, and the ruptured portions of the heretofore united crust floated about on the liberated waters and became continents and islands, according to their sizes, whilst other pieces of the crust, being forced upon their beam-ends, became converted into mountain-chains. This is a simple, if not very accurate explanation of Nature; but the careful study of geology in the past hundred years has led to our being shown a more excellent way of interpreting the groundwork of Nature. We find that many and varied forces have contributed to bring about the present configuration of our earth's surface, and although the main land-masses and the deeper oceanic depressions were doubtless sketched out in Palæozoic times, yet the minor details resulting from later sedimentary deposits in shallower seas, the elevation of mountain-chains, the carving and shaping of land-surfaces, and the production of plateaux and steppes, of hills and valleys, all in fact which constitutes our scenery, is but a thing of yesterday, geologically speaking, although the expression "old as the hills" still remains perfectly true when comparing Nature's smallest operations with the pigmy events and periods in man's ephemeral calendar of existence.

When one looks at the long array of geological textbooks upon one's bookshelf it seems at first difficult to accept the justice of Lord Avebury's indictment that our geological literature is very much scattered, that it has to be sought for in innumerable memoirs,

Curve on the Wye near Chepstow.

[From "The Scenery of England and Wales," by Lord Avebury (p. 296) : Macmillan & Co.]

Lower Fall, Aysgarth, Wensleydale, Yorkshire.

[From "The Scenery of England and Wales," by Lord Avebury (p. 335): Macmillan & Co.]

or in the publications of learned and often of local societies; but there is, after all, much truth in this aspect, and more still in the fact that very few of our geological writers possess the happy method of placing the dry bones of our science in an attractive manner before the ordinary reader, or can show that there is a romance and poetry in the geological aspect of "hill and dale and wooded grove," which may even move the commonplace reader, or the ordinary man in the omnibus, to enquire what are the causes which have brought about the present scenery of England.

In the earlier days of our science, geological observers dealt largely in cataclysmic and paroxysmal action, and firmly believed in the *sea* as the great denuding agent, assisted by the frequent and often sudden elevation or subsidence of the land by volcanic or earthquake movements, and that to these agencies the wearing away and carving out of the land were chiefly due.

One is readily impressed by noise and commotion; thus the loud striking of the clock affects one's nerves more forcibly than the gentle yet constant oscillation of the pendulum, doing its ceaseless yet silent work. So, too, in Nature the lightning and thunder of the tempest, the eruption of the volcano, the violence of the earthquake, and the roar of the storm-swept sea, vividly impress our imagination; but it needs a careful observer to appreciate the work of her quieter but ceaseless agents, the sun, the atmosphere, frost, snow, and ice, and her constant carriers, rain and rivers.

Lord Avebury cites Mackintosh's "Scenery of England and Wales" "as an illustration of a work written under the belief that the configuration, and consequently the scenery, was mainly due to marine action." "Subsequent researches have led to, I think, a general agreement that subaerial action has been the predominant partner." Again, "The sea" (writes the author) "can only act along the coast-line; rain is ubiquitous." "Sea-erosion is horizontal and leaves headlands; rain-erosion is vertical and leaves hills; along the coast the harder rocks stand out, inland they stand up" (p. 136).

It was because of their apparent insignificance that rain and rivers, frost, snow, and ice were at first neglected by geologists; now we see the vast importance of these agents, whilst still crediting the sea, the volcano, and earthquake with their due. In the pages of this Magazine may be found numerous articles by Mr. Poulett Scrope (1866), Sir A. Geikie, Mr. W. Whitaker (1867), Colonel Greenwood, and many other writers, showing how fully the effect of subaerial denudation has been understood and advocated by all advanced geologists long since.

But to return to "The Scenery of England." The first two chapters are devoted to sedimentary and other geology, and give the reader an epitome of the igneous and sedimentary rocks from the Archæan to the Quaternary, the latest having by far the larger share of space given to them, for, although the youngest and most superficial deposits, they affect the present surface of the ground, and often mask the older rocks beneath Drift and Boulder-clay, or beds of gravel and sand, erratics or peat. The chapters which follow deal with the general Configuration of our Island; the Coast; the Origin of Mountains; Volcanoes; the History of Rivers, their Courses; Lakes; the Influence of Rocks on Scenery; Downs, Wolds, Fens, Moors, and Commons; Law, Custom, and Scenery; Sites of Towns; and Conclusion.

The full enjoyment of our scenery can only be realized by those who, while admiring its picturesqueness, recognize that the wonderful story of its origin and development is still more absorbing. It is no longer difficult to acquire an elementary knowledge of the mode of deposition of the sedimentary rocks, of their position in the geological series, and of the fossils which characterize them.

To those who have not already studied the subject, the first chapters in Lord Avebury's book will provide a most useful introduction, and, like the draught and pills of the apothecary, the book may be accompanied by a dose of Woodward's Table of British Strata and Geikie's Geologically Coloured Map of England and Wales, each hanging from its appropriate nail on the library wall, ready for reference. As a matter of necessity in such a book, mountains, hills, rivers, and lakes occupy an important place, and of necessity fill a large space (eight chapters and nearly 250 pages) in the scenery of England.

And here, parenthetically, we would venture to ask his Lordship, since he includes Wales in his book, why does he not call it the "Scenery of England and Wales"? It must be on the principle that the greater includes the less; nevertheless, the Principality, with a population of 1,698,161 and a Prince of its own, will surely rise up to a man "to know the reason why" Snowdon is spoken of as "our loftiest *English* mountain"! Spirit of Owain Glyndwr du (Owen Glendower), awake! arise! defend thy heritage as of old.

There are few points in the physical geography and scenery of our country which can be explained without a clue from its geological construction. In the peculiar courses followed by some of our rivers, which occasionally take an apparently inexplicable turn at nearly a right angle, the secret may lie in the direction taken by great lines of fracture in the rocks. In general the great lines of uplift and the varying nature of the rocks have exerted most influence. The subject is a complex one, but the history of rivers is fully dealt with by the author in the light of the most recent researches on the subject.

It is, perhaps, unfortunate that figures should ever be used to express the immensity of geological time. There are few readers who can realize the meaning of 100,000,000 years, which the author says must have elapsed since the commencement of life on our planet, or of 200,000 years since the beginning of the Glacial Period, or even of the 50,000 years before our time at which that period may have ended. Geological time is better expressed in terms of the changes which have taken place during its progress. "The top of Snowdon was once the bottom of a valley"; "Our Scotch and Welsh mountains are so low because they are so old," as compared with the Alps, Himalayas, and other ranges, which are, indeed, all newer than the London Clay. Phrases such as these convey the idea of geological time better than ciphers.

In the later chapters we seem to be walking by the side of the writer by rivers, lakes, and sea-shore; over downs, fens, moors, and commons. Everything he tells us is full of interest, and he leaves nothing untouched. Geology, scenery, animal life, botany, history, ancient laws and customs, anecdote, poetry, all are there. As to illustration, the book may be considered as a small but very choice photographic album of English scenery. We introduce two only, out of nearly 200 pictures, but they are all so excellent in their several ways that one needs the book itself to realize how good they are.

In his preface the author says: "If the book be half as interesting to read as I have found it to write, I may venture to hope that it may serve as an introduction to this fascinating branch of science." It is not only interest that Lord Avebury introduces into his subject, but enthusiasm. J. A. W.

II.—Geological Survey of Canada. G. M. Dawson, C.M.G., LL.D., F.R.S., Director. Annual Report (New Series), Vol. XI: Reports A, D, F, G, J, L, M, R, S. Plates and Maps. (Ottawa: S. E. Dawson, 1901.)

BEFORE beginning this notice of the work of the Canadian Geological Survey the writer, as an old friend and former colleague of the late Director, craves permission to record his deep regret at the great loss suffered by the Survey in the death of their chief, a loss which seriously affects alike geological science at large and that of the country which was the field of his labours.

The Summary Report (A) by the late Director need only be briefly touched upon, as it relates, for the most part, to work which has already been passed under review in this Magazine. It concerns, as usual, the explorations and surveys in progress at the time, the publications connected with the museum, and the work carried on there and in the offices attached to it. Perhaps the most interesting observations are those relating to the Klondike Gold District by Messrs. R. G. McConnell and J. Burr Tyrrell. We learn from them that the productive area traversed by the gold-bearing creeks is 1,000 square miles. The gold occurs in the gravel flooring at the bottom of the valleys, and in stream-terraces lining their lower slopes. The gravels rest on an irregular floor of decomposed mica-schist and quartz-schist, underlying which is a quartzose, micaceous, and sericitic schist (the rock of the district), of sedimentary or volcanic origin, highly altered by dynamic agencies. This rock is of early Palæozoic, probably Cambrian age.

The great richness of the Klondike placer ground depends, first, on the presence of a highly gold-bearing rock, and secondly, on the occurrence of a set of conditions peculiarly favourable to the concentration of the precious metal.

Mr. D. B. Dowling's report (F) treats of the geology of the west shore and islands of Lake Winnipeg, the notes prepared by Mr. J. B.

Tyrrell, his predecessor, being used to make the descriptions of the formations more complete. The first part of the report is occupied with a detailed account of the physical geography of the area surveyed. A table is given correlating the formations of Manitoba and Minnesota, and a long list of fossils from the Cambro-Silurian (Ordovician) of Manitoba, including those of the Trenton and Black River of Lake Winnipeg compiled from the "Palæozoic Fossils," vol. iii, of Dr. J. F. Whiteaves.

The next report (G), by Mr. J. Burr Tyrrell, "On the east shore of Lake Winnipeg and adjacent parts of Manitoba and Keewatin," is compiled by Mr. Dowling from Mr. Tyrrell's notes and surveys. It takes the shape of a description of the lake, starting from the northern end and going southward. A carefully prepared topographical and orographical account serves as an introduction; the geological features follow. The rocks are Archæan, the great preponderance of gneisses and granites of the Laurentian being the chief feature; there are also local occurrences of Huronian greenstones and schists. A coloured geological map of the lake on a scale of 8 miles to 1 inch accompanies this report.

Dr. R. W. Ells contributes a report (J) on the geology of the area comprised in the north-west quarter-sheet of the "Eastern Townships" map, or Three Rivers sheet, of the Province of Quebec. The Palæozoic formations observed are the Potsdam, Calciferous, Chazy, Black River, and Trenton to the north of the St. Lawrence River, and the Utica, Hudson River, and an outlier of the Medina in the small area to the south of the St. Lawrence included in the tract of country surveyed. Full lists of the fossils obtained are given, their identification having been entrusted to the competent hands of Dr. H. M. Ami. Some crystalline rocks of the "Grenville Series" also occur, with large areas of anorthosite, red granite, augen-gneiss, and masses of green pyroxenic diabase. The map accompanying this report is drawn to a scale of 4 miles to 1 inch.

Mr. A. P. Low's report (L) contains an account of his exploration of part of the south shore of Hudson Strait, and of Ungava Bay. These distant expeditions are not without their elements of danger and adventure, and the narrative of the voyage in a sealing steamer from Halifax to Hudson Bay *viâ* the Straits of Belle Isle, and the subsequent incidents of the coasting voyage in a small yacht along the shore of Hudson Strait, serve fully to impress this upon the reader. Making their way slowly through pack ice, and with many delays, the voyagers reached Hudson Bay on the 12th July, having left port on the 3rd June. Leaving the steamer in King George Sound they took to their small yacht. The route lay along the coast from the Sound to the head of Ungava Bay. The nature of the country, as far as could be seen from the coast and from some of the streams, is described as high, rocky, and barren, and this description is fully realized in the illustrations (from photographs) which accompany the report.

The long line of coast explored in the limited time at the disposal of the expedition admitted only of a hurried examination each day.

The rocks met with were all found to be of great antiquity, all more or less altered by pressure induced by intrusions of igneous masses, which folded the bedded series and produced foliation in much of the otherwise massive granites, gabbros, diabases, and other greenstones. The foliation of the granites shows that the pressure was exerted from a direction varying from west to south-west. Where massive beds of cherts and quartzites resisted the folding action, they with their associated beds of softer shales or slates have been shoved into ridges by overthrust faults, giving the hills cliff-faces inland, while their seaward slopes conform closely with the dip of the beds.

The gneisses seem to be metamorphic products of several rocks of different age and origin. Some of them probably represent part of the original Archæan complex; others may represent granites of a somewhat later date, injected into the first, but long anterior to the time of deposition of those sedimentary beds of Labrador that have been provisionally classed as Cambrian.

Glacial action has left its traces everywhere, the entire coast having at one time been covered by an ice-sheet sufficiently thick to override the highest hills.

A short chapter on the marine terraces which mark the limits of the subsidence of the land brings this interesting report to a close.

Dr. Bell's report (M), which follows, deals with the northern side of Hudson Strait. Baffin Land, a treeless region like that of the southern side of the strait, is made up principally of Laurentian rocks; a considerable area, however, of flat Silurian limestone borders the western shore in Fox Basin, and extends inland to Lake Nettilling. Satisfactory evidence is given of the occurrence of the Trenton and Utica formations, and it is stated on the authority of Professor Schuchert, of the United States National Museum, that the Baffin Land fauna had, like that of Manitoba, an early introduction of Upper Silurian.

It is added that among the Arctic islands northward of Baffin Land large areas of Upper Silurian rocks are known to occur associated with strata of Lower Silurian age.

Three appendices contain (1) observations of latitude made by Dr. Bell, (2) a list of plants collected by him in Hudson Strait, (3) a short list of Lepidoptera.

The scenic features of the country are, as usual in these reports, well brought out by photographic reproductions.

Dr. Hoffmann's report (R) of the section of Chemistry and Mineralogy consists of mineralogical notes and analyses of various ores, and of natural waters, also gold and silver assays.

Mr. E. D. Ingall contributes a report on mineral statistics and mines for 1898, which begins with a general table of the mineral production of Canada for a period of thirteen years, representing the work of the Mines Section of the Geological Survey. These statistics show that Canadian mining industry is in a very flourishing state.

The last eighteen pages of the volume are devoted to a very serviceable index in double columns. ARTHUR H. FOORD.

OBITUARY.

OTTO MARTIN TORELL.

(PLATE XV.)

BORN JUNE 5, 1828. DIED SEPTEMBER 11, 1900.

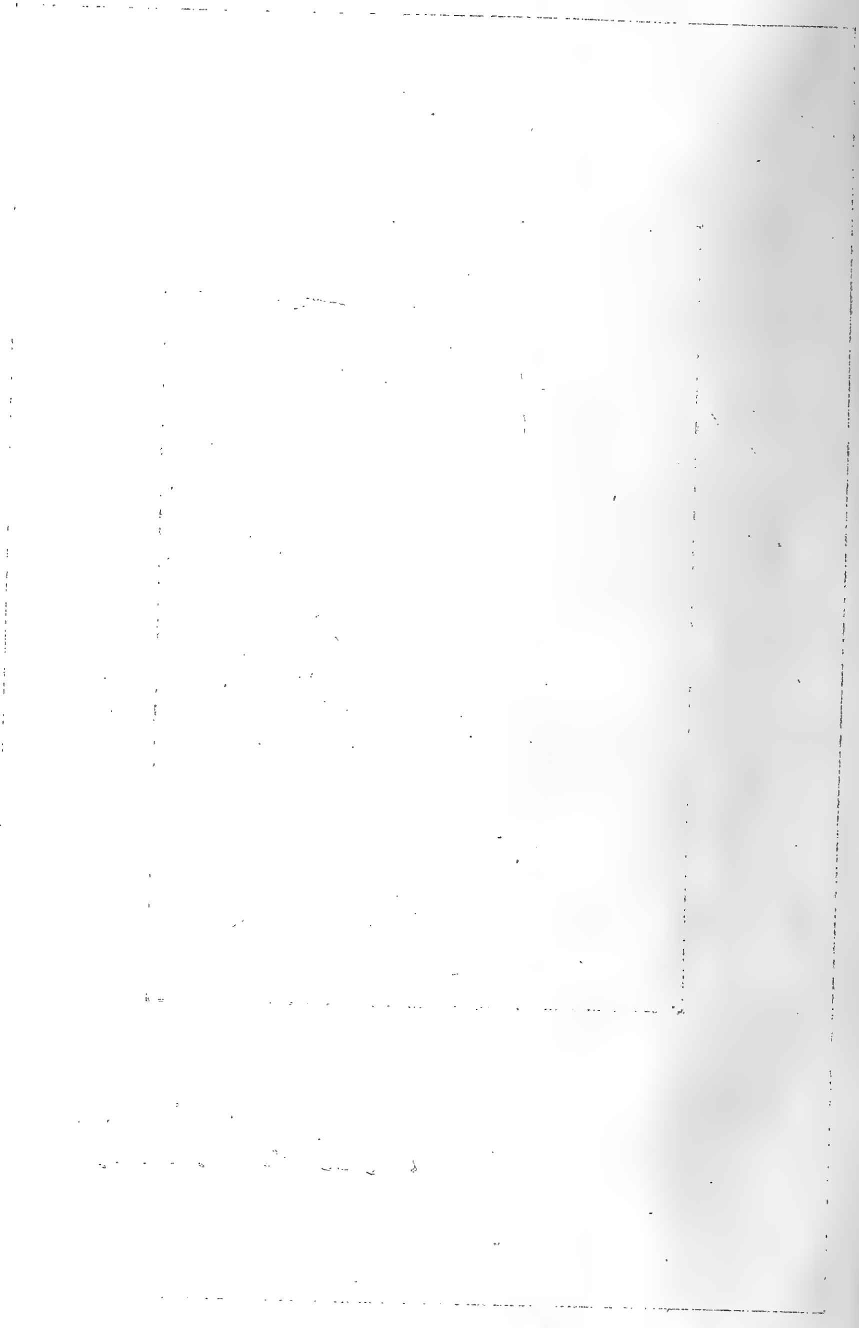
THROUGH the kindness of Mr. Leonard Holmström, we are enabled to present our readers with an excellent portrait of the late Professor Torell, who from 1871 to 1897 was head of the Geological Survey of Sweden. The portrait originally accompanied a long article by Mr. Holmström in *Geologiska Foreningen i Stockholm's Förhandlingar* (xxiii, Häft 5) issued at the close of last year. Space does not permit us to publish even a condensation of this highly interesting account of the departed geologist, but Torell was known personally to so many of his colleagues in this country, which he frequently visited, that they will welcome some extracts therefrom.

Torell wrote little, partly from a disinclination for the mere physical act, partly from a striving after that completeness which can so rarely be attained, partly from a carelessness of personal fame, and partly perhaps because he was rather a propounder of new ideas than a patient elaborator of detail. His influence therefore on the geologists of the world was not quite so great as it might have been; but on those of his own country it was enormous. Mr. Holmström goes so far as to call him "in one sense *the creator of Swedish geology*. It is true that Sweden could show men eminent in that branch of learning before Torell's time, but it was not till his coming that geology was generally recognized as an independent science. He founded a school of geology in the University of Lund, which possessed neither professor, nor literature, nor collections for its study, and where even to-day there is no full professorship in the subject." . . . .

"He transformed the official Geological Survey of Sweden into a scientific institution of high rank. He himself was the founder of a truly scientific geology of the Quaternary period, through his genius and courage in championing the theory of a general glaciation of northern Europe, and for all time his name will be coupled with that bold hypothesis, which fought its way to victory in the teeth of contempt and official excommunication." On his first appearance before the German Geological Society, the geologists of Berlin could not listen to him with patience; but five years later they made him a chairman at their annual gathering.

It was in pursuit of evidence for or against his theory of an inland ice-sheet that he began the series of Arctic expeditions of which Sweden has such right to be proud, sacrificing to them no small part of his own means. A. E. Nordenskiöld, who was his companion, reminded us not long before his own death, that Torell's first expedition to Spitzbergen (1858) was made in an ordinary clinker-built fishing-smack, which leaked even before she left

Otto Torell.



Tromsö. Several of Torell's letters to Nordenskiöld are quoted by Mr. Holmström, and it is interesting to read the words: "for many years the quest of the Pole has been my *idée fixe.*" None the less the Swedish expeditions have never been mere foolhardy or sensational attempts to beat the record of high latitude, but have borne that truly scientific character which Torell impressed on them from the first.

Instigated by Lovén, under whose penetrating influence he came at the age of 20, he undertook dredgings at Kristineberg, where now is the Swedish biological station, and it was here that he found *Yoldia arctica* in the fossil state. This discovery propounded the question as to the nature of former Arctic conditions in southern Scandinavia, which in after life he did so much to answer. At that time, however, the medical profession was his goal, and while conducting researches in comparative anatomy under Lovén, he also accompanied him on dredging expeditions in yet deeper waters, and accomplished much on his own account, especially on his journey to Iceland.

Whether as teacher at Lund, as friendly companion, or as head of an official establishment, Torell lost no opportunity of imparting some of his own enthusiasm to others, whether students, politicians, or wealthy landowners. He freed the Survey from the bonds of a rigorous officialdom, and encouraged the independent scientific work of the members of his staff in every possible way. But eager though he was to encourage science for its own sake, he was no less keen to apply it to the advantage of his native land. He conducted or instigated numerous surveys, both official and private, of the agronomic and technical geology of important districts. He founded the great cement industries of southern Sweden, bored for oil in the Silurian shales of Dalecarlia, showed the towns of Lund, Malmö, and Helsingborg how to get a constant supply of pure artesian water, helped to develop the sea-fisheries of Sweden, set on foot researches into the marl beds and phosphorite beds, and all materials suitable for the enrichment of the soil, fostered the building-stone industry, sought out uses for the vast deposits of peat, was a pioneer in the employment of water-gas, promoted railways to exploit the resources of northern Sweden, and toiled, albeit unsuccessfully, at the problem of extracting iron directly from the malm-ores.

Torell never became, as he intended and even wished, a practising physician. But he did not at first find the pursuit of pure science a satisfactory career, and in 1867 he even had thoughts of settling in England, which shows how bad things must have been with him. However, the appointment to the Geological Survey came at the right moment, and Sweden kept for herself one of her most eminent men of science and one of the most patriotic of her sons.

F. A. B.

MISCELLANEOUS.

Presentation of a Gold Medal to Professor Albert Gaudry, Memb. de l'Inst. de France; For. Memb. Royal and Geological Societies, London; etc., etc.

On the 9th of March, at the Muséum d'Histoire Naturelle of Paris, a gold medal was presented to Professor Albert Gaudry by his pupils, friends, and admirers, in order to commemorate the fiftieth anniversary of his connection with the Museum. Over forty French and foreign Academies and scientific bodies had either sent delegates or forwarded written addresses. The principal speakers were Professor Edmond Perrier, Director of the Museum, Docteur Marcellin Boule, Gaudry's pupil and assistant, and Monsieur Liard, "Directeur de l'Enseignement supérieur," representing the Government.

In Gaudry's monumental work "Animaux fossiles et Géologie de l'Attique," as well as in all his other publications, the two qualities which make the ideal scientist are happily blended together. His broad speculations are solidly rooted upon a minute morphological analysis, accompanied by clear and concise descriptions. It will, as time goes on, be still more universally and gratefully acknowledged than at present that Gaudry—and, at exactly the same time, Rütimeyer—were the first palæontologists who courageously stood up for the doctrine of Evolution with solid arguments based on laborious researches. This, which is one of Gaudry's chief glories, was duly accentuated in M. Boule's discourse. "You will never know sufficiently, my dearest master, how large has been the influence you exercised, towards 1880, on the youths who frequented the natural history amphitheatres. Your book (*Enchaînements du Monde animal*) had not only for us the attraction of a splendid scientific work, we considered it also as an act of independence and of courage. In fact, twenty years ago, the majority of our professors were hostile to the theory of Evolution; some of them kept themselves in a prudent reserve; very few were daring enough to base their teaching on the theory of evolution; they had for adversaries the princes of science, the dispensers of appointments and of favours. Your *Enchaînements* convinced those naturalists who had not been persuaded by argument taken from comparative anatomy or embryology. Your conclusions were based solely on the patient study of facts; they were real proofs, and have been of considerable weight in ensuring the triumph of the new ideas."

Besides the scientist there is the man. "L'essence de votre nature c'est la bonté," said Boule to his beloved master, and all of us who enjoy the privilege of personal acquaintance with Professor Gaudry gladly and heartily endorse these words.

After fifty years labour devoted to the building up and arrangement of the magnificent collections displayed in the Museum of Palæontology in the Jardin des Plantes, Professor Gaudry retires to the enjoyment of his well-earned repose, carrying with him the loving regard and earnest good wishes of a very wide circle of friends and men of science in all parts of the world in which his name and writings have become known and warmly appreciated. F. M.

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ORIGINAL ARTICLES.

I.—Creechbarrow in Purbeck.

By W. H. Hudleston, M.A., F.R.S., F.G.S.

I. Introductory.

THE Isle of Purbeck possesses numerous points of geological interest, and its coast scenery has been celebrated, in conjunction with that of Lulworth, by many writers and artists. The classical work of Sir Henry Englefield, assisted by Webster, in the early part of the last century, served to make known some of the most interesting features of the coast, such as are more or less obvious to all who venture to sail beneath its cliffs. Of late years the geology of the Isle of Purbeck has attracted the attention of the officers of the Geological Survey, and has come in for a considerable amount of description at the hands of H. B. Woodward, Aubrey Strahan, and Clement Reid, in their respective departments. The zones of the Chalk in this region have also been admirably described by Dr. Rowe and his coadjutors, mostly from coast sections.

The interior of the Isle of Purbeck has likewise attracted a fair amount of attention, and those who have participated in some of the excursions of the Geologists' Association during the last quarter of a century will not be altogether ignorant of its leading features.

One of the chief of these features is the long 'Purbeck Hill,' consisting of a narrow outcrop of Chalk, tilted at a high angle towards the north, which stretches from Arish Mell Gap, just underneath Lulworth Castle, on the west, to Swanage Bay on the east. The celebrated 'overthrust' fault, the subject of many a drawing and photograph, is seen in the middle of the Chalk formation between Ballard Point and Old Harry on the northern horn of Swanage Bay, which also forms the most easterly point of the Isle of Purbeck. The effects of this fault, or axis of maximum tension, may be traced for the most part along the northern slope of the Purbeck Hill, though its effects are not so obvious as in the Lulworth district further to the west. The principal fact to be noticed in this connection is that the so-called Purbeck Hill may be said to divide the Isle of Purbeck into a southern and a northern area, and it is to this latter region, which is wholly composed of Tertiary strata, that I would direct attention.

The maximum elevation of the Purbeck Hill is about 650 feet, and its average height might be somewhat under 500 feet; it is breached at Corfe Castle, whence the drainage of part of the southern area escapes through a sort of double gap in the Chalk to flow across the low-lying Tertiary area to the northwards. Practically, with this exception, the Purbeck Hill presents an unbroken range of considerable steepness to the Tertiary district comprised within the Trough of Wareham, and which, as far as the river Frome, is regarded as forming a portion of the Isle of Purbeck. There is, however, a remarkable object which breaks the somewhat monotonous outline of the long Purbeck Hill, and that is the conical figure of Creechbarrow, which rises, all alone, at a little distance northward to a height of 637 feet, and is composed, not of Chalk, but of Tertiary strata. Seen from certain points Creechbarrow looks like a pimple on the Chalk ridge itself, whilst from other positions its peculiar outline greatly resembles a volcano, and when there happens to be a gorse fire near the summit this impression becomes almost a reality.

Geologists will readily understand that there is nothing igneous about Creechbarrow, but for all that its origin is extremely enigmatical. Why a mass of Tertiary beds should stand out, like a sentinel, in front of a long line of Chalk hills, rivalling these Chalk hills in height, whilst the bulk of the Tertiary strata in the neighbourhood are almost wholly below the 300 feet contour, was always a puzzle to me, as it evidently was to the earlier members of the Geological Survey. Day after day and month after month at intervals during the past four years have I noticed that graceful hill under every conceivable atmospheric condition, until the desire to account for its exceptional presence grew stronger within me.

Animated by these sentiments I succeeded in inducing the chiefs of the Dorset Natural History and Antiquarian Field Club to arrange for an excursion to Creechbarrow last Summer. The Fates accorded us a beautiful day, and the "West Purbeck Meeting" on the 21st of August last was attended by something like 100 people. Lord Eustace Cecil presided in the absence of Mr. Mansel - Pleydell through illness, and under his auspices I endeavoured to expound my views from that airy spot. My remarks are fully recorded in the Proceedings of the Dorset Field Club.[1]

Amongst other points that were urged I endeavoured to impress upon the meeting the exceptional character of Creechbarrow, and for this purpose I entered into the physical description and history of the Purbeck Hill, the Trough of Wareham, etc., at some length.

Since we had the map of Nature before us there was no need of a diagram, but in order to bring the subject home to those at a distance I submit the accompanying diagrammatic sketch of the Trough of Wareham.

[1] Vo'. xxii, p. liv.

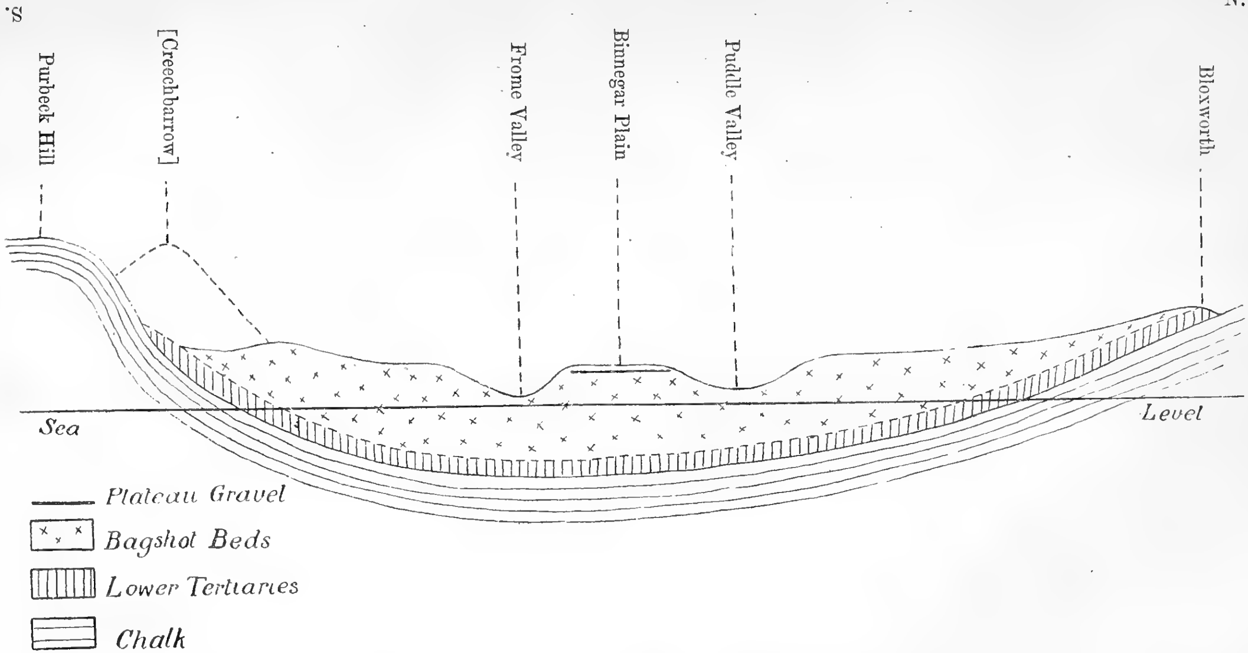


Fig. 1.—The Trough of Wareham.

Note.—If this diagram were continued in a northerly direction it would be found that the Chalk ultimately rises in the Dorset Downs to heights considerably exceeding that of the Purbeck Hill, thus completing the figure of the great Dorset syncline.

This diagram, which has an horizontal extension of about 8 miles from south to north, is intended to represent the *general* topographical and geological structure of the Trough of Wareham on a meridian both east and west of Creechbarrow. The section itself may be taken more particularly to represent a meridional line to the westward of that hill drawn through West Creech, Binnegar, and Bere Heath. Accurate detail is not attempted, but the thoroughly exceptional character of Creechbarrow can be gathered from the dotted outline of the hill itself, projected on the section. We perceive at a glance that the Tertiary beds in this hill are just twice as high above sea-level as they are in the *normal* or *general* section between the Purbeck Hill and the Frome River. The latter is the northern boundary of the Isle of Purbeck.[1]

Having thus impressed upon the meeting the thoroughly exceptional character of Creechbarrow in its relation to the rest of the Tertiary beds in the neighbourhood, I next endeavoured to adduce some reasons for the explanation of this anomaly. Premising that hills, as we see them now, are the outcome of certain elevating forces of a remote period, and that they have been fashioned by meteoric agencies, which themselves are modified by various internal and external peculiarities, I offered three possible suggestions or theories to account for the existence of Creechbarrow as we now see it, and for its exceptional relation to the Bagshot Beds of the immediate district, which largely consist of potter's clays of different qualities (the Pipeclay beds).

(1) The first of these suggested explanations may be summed up under the heading "Exceptional development of the Creechbarrow Beds themselves." It is well known what valuable workings in the clays at the foot of the Purbeck Hill have been carried on for nearly a century. This has been one of the most important industries of East Dorset. We may trace the line of the old workings exactly as if drawn on a map all the way to Corfe Castle. An old workman who had long been engaged on this business pointed out to me some time ago that *Creechbarrow bulges all these beds and throws them out of line.* Such a state of things tends to prove that there is something peculiar in the original composition of this monticle. It may be inferred also from the above statement that the Creechbarrow Beds contain no potter's clay. An inspection of the map showing the curve of these workings will prove at once how correct was the old workman's remark about the bulging of the Pipeclay series.[2] So much for theory No. 1.

(2) The second explanation, or rather suggestion, had reference to the proximity of the great thrust-plane which governs the tectonic constitution of so much of the Isle of Purbeck. "It is

[1] The general structure of the Trough of Wareham is no doubt that of an undulating syncline, but owing to the softness of the Bagshot Beds accurate stratigraphy is not attainable. I am inclined to believe that the original bottom of the syncline is represented by the Plateau-gravel on Binnegar Plain, and that both the Frome and Puddle Valleys have been excavated subsequently.

[2] Map to accompany the forthcoming paper in the Proc. Dorset Field Club.

represented in the geological map as passing along the junction of the Chalk and Tertiaries about 300 yards to the south of our present position [i.e. on Creechbarrow]. It is quite possible that, instead of sticking to that route, the line was deflected somewhat, so that the thrust-plane has come in among the Tertiary clays. . . . The great thrust from the north has pressed these clays against the hard Chalk, making them harder and fitter to withstand the forces of denudation."[1] Remarkable instances of derangement of the strata and reversal of dip have been experienced in the pipeclay workings, and the Chalk itself is found to be dipping to the north at an angle of 80° at the limekiln which is close to Creechbarrow. In consequence of such evidence of the effects of the Isle of Purbeck thrust-fault in this immediate district, it occurred to me at that time that exceptional tectonic forces, locally exerted, might possibly have had something to do with the formation of this peculiar hill. So much for theory No. 2.

(3) The third explanation offered was the most theoretical of all, as it involved a spread of Plateau-gravel on the summit of Creechbarrow at some period of its history. Everyone knows how largely the Plateau-gravel has contributed to the formation of high ground, more especially in the Bagshot districts of Surrey, Hants, and Dorset, so that what was originally a shallow valley, owing to the protection afforded by an accumulation of flint gravel, often cemented by iron-oxide, becomes relatively high ground and sometimes even a hill.[2] On this occasion I went so far as to express my belief that there had been Plateau-gravel on the top of Creechbarrow. The principal evidence for this hypothetical bed of gravel arises from the fact that about a thousand yards from the summit of the hill on the north side, near the 300 feet contour, there is a large deposit of clayey gravel, which is worked for road-metal and probably for other purposes. This bed of gravel, it then appeared to me, might be the remains of a deposit once at a much higher elevation, which had, to a certain extent, been slid off these slippery clays, especially during a period when there was a great deal of snow, which would facilitate deposit on the north side of a slope. Another indication of this supposed gravel bed on Creechbarrow, which was then present to my mind, arises from the great number of peculiarly large flints which may be seen about the hill. They are, for the most part, unabraded flints, and their position is such as to suggest that many of them may have rolled down from the upper part of the hill, though they are now to be noticed principally on the eastern base. These loose flints I held as additional evidence of the existence of my hypothetical gravel bed on the top of this hill. So much for theory No. 3.

[1] Op. et vol. cit., p. lviii.

[2] The valley-flat of days gone by
Becomes the plateau, high and dry:
Thus, in the cycle of the Ages
The Drifts reverse their earlier stages.
ANON.

The address concludes with the following remarks:—

"But we cannot say what the hill itself consists of, for the whole hill, especially the top of it, has been thoroughly sophisticated. I have not the remotest idea of what the original surface of the summit consisted. This tumulus, which forms such a convenient shelter, is composed of those very large flints which have been gathered from all around. But the greatest annoyance is that a house has been built on the top of Creechbarrow, and the foundations and walls make it utterly impossible for anyone to judge what may have been the original composition of the summit. It has been sophisticated by man, and the only way I can see of ascertaining the true structure of Creechbarrow is to drive a horizontal level right in to see what the hill is really made of. If the Dorset Field Club would like to vote a sum of money for that purpose, I will undertake to see that it is properly spent. But I am afraid that this is hoping rather too much."[1]

II. Investigation.

Acting on my own suggestion, as conveyed in the preceding paragraph, having first obtained the permission of the owner and occupier, I set some men to work digging in October last, and we very soon arrived at most unexpected results. The remarkable greensward on the very summit of Creechbarrow, so different to the vegetation of the typical Bagshot districts, where heather and Iceland moss afford a meagre diet to the rabbits, had always provoked my suspicions. No one, however, had ever suspected that the actual summit of Creechbarrow consists of LIMESTONE, but now we perceive that the calcareous nature of the soil is chiefly accountable for this unwonted greenery at such an elevation.

Altogether some seven or eight pits were dug within the limits of the 600 feet contour. It is not intended to specify in the Geological Magazine the particulars of these, but it is hoped that such details as may be of interest will appear in the forthcoming volume (No. 23) of the Proceedings of the Dorset Field Club. The first pit (No. 8*a*)[2] was dug in the eastern flank of the summit ridge, some distance below the actual summit. Here a calcareous talus was encountered before the solid geology of the hill was reached. This calcareous talus created great surprise, and many were the conjectures as to its origin. The material was mainly in a chalky condition, and as there were no fossils to guide us we concluded that some chalk had been brought up to the top of the hill. Then, again, remembering that the foundations of the house formerly existing on the summit consisted of dressed Purbeck stone, we fancied that a sufficient quantity of Purbeck stone might have slipped down to form a talus—and this seemed the more probable, as the less perished stones had rather the look of a fresh-water limestone: so the theory of a Purbeck, or even a Portland origin, prevailed over the original supposition of derivation from the Chalk. At that stage of the investigation we never dreamt

[1] Vol. cit., p. lix.

[2] These figures refer to the numbering ultimately adopted.

of an autochthonous deposit of limestone on the hill itself. When the calcareous talus was penetrated in this section, we found the solid geology to consist of a peculiar cakey sand, passing down into buff-coloured sands with vertical tubes having a calcareous lining. Underneath this was an irregular layer of flints, some of great size, about a foot thick, and lower still loose white sand, preceded by yellow sandy clay blotched with oxide of manganese and containing perished flints.

So far as I know, these yellow manganese-stained sands and clays, in conjunction with the flint beds and the concretionary limestone subsequently discovered, make up the hill-top of Creechbarrow, that is to say, of the area within the 600 feet contour, some three or four acres in extent. Since the source of the limestone fragments in the talus had not yet been discovered, we made an excavation a few feet higher up (No. 8), and there we had the satisfaction of detecting a massive tufaceous limestone with an irregular surface passing downwards into sand with calcareous concretions, and this excavation was carried down to a layer of flints which was not pierced. Whether this is the same as the layer in the lower pit one cannot say.

Before proceeding to describe the complete discovery of the limestone, I will draw attention to the problem suggested by the flints. It will be remembered that when in August last I offered three possible suggestions as to the origin of Creechbarrow, I laid considerable stress on the abundance of flints knocking about over the hill, as evidence of the former existence of Plateau-gravel upon or near the summit. It was now proved that these large and peculiar flints which one associates with Creechbarrow are not by any means derived from any superficial deposit, but that they constitute an important part of the beds of which the hill is composed. These beds are undoubtedly of Lower Tertiary age, and if we assume, in default of evidence to the contrary, that they are of Bagshot age, at least these flint beds constitute a portion of the series, whatever it may be. But in order not to prejudge the question of age, I will simply speak of the whole series as the *Creechbarrow Beds*.

In describing certain sections further on the subject of these bedded flints will again crop up, but we may note some peculiarities with reference to them now. It must always be borne in mind that these flints are large stones in the midst of extremely fine sediments. There are, no doubt, throughout the Creechbarrow Beds, as elsewhere in the Bagshots, coarse iron-grits and lydite gravels, such as the people in the neighbourhood call 'granite gravel.' Still, the bulk of the deposits, whether of sand or clay, are of fine material, and yet these large flints occur in abundance, not only disseminated occasionally through the clays and sands, but accumulated in beds of varying development up to 4 feet in thickness. These flints have for the most part a creamy appearance, they are much degelatinized, and in some cases the exterior is simply a mass of granular silica, very meagre to the touch. They are also extremely brittle when first dug out, though I rather think that exposure to the atmosphere toughens them after a while. In consequence of this brittleness the available fragments do not much exceed 28 lbs. in weight, so far as I have seen them, though it may well be that much heavier flints than these occur. The surface of those flints which are not much broken has been subject to very little modification from abrasion. Associated with the big flints are flint pebbles and other stones of moderate size, also quartzose grit.

Having ascertained the undoubted existence of indigenous limestone on Creechbarrow, it became necessary to obtain some further knowledge both of its mode of occurrence and general character. Pits were opened in one or two places, and especially on the summit. Before proceeding to describe the summit pit (No. 5) I will submit the section of No. 4 pit, which is on the south slope of the actual summit and forms part of the escarpment (see Fig. 4, p. 255).

The following sequence was observed :—

	ft.	in.
1. Soil with few flints, fragments of pottery, oyster shells, etc.	1	6
N.B.—A deposit of this nature forms a sort of talus to the whole section on the hill-side.[1]		
2. Softish tufaceous limestone	2	6
3. Passing downwards into sands full of calcareous concretions	4	0
4. Band of yellow clayey sand	0	6
5. Loose buff-coloured sands	5	10
6. Layer of large flints of the Creechbarrow type ...	1	0
7. Pale buff-coloured sands (not bottomed)	4	0
Total	19	4

For convenience this section was cut in three steps. It was here that the principal evidence for dip was obtained. No bedding was observable in the tufaceous limestone, and the irregular nature of its base causes it to be of little use for stratigraphical purposes. The thin band of "yellow clayey sand" was more useful, and also the "flint layers," so that from these and other indications an inclination of 9 inches in 48 inches was observed, the direction being somewhat to the west of north, or at any rate northerly. This may be calculated into an incline of 1 in 5·5 = 11° nearly. The identification of the particular flint band in another pit, supposing such identification to be correct, serves to confirm the amount of dip and also the direction. The longer axis of the hill itself runs in a direction about N.N.E., being nearly at right angles to the trend of the long Purbeck Hill, and this peculiar conformation is especially noticeable from many points in the Frome Valley. The great bulge which the Creechbarrow Beds impress upon the Pipeclay series has the same direction as the longer axis of the hill. Hence the observed dip and the dip slope (see Fig. 3) are slightly divergent. On the whole, without attempting an accuracy which in beds of this

[1] As regards these deposits in the soil and in the semi-artificial talus, I have the following note :—Black soil with pottery, oysters, limpets, mussels, periwinkles, bones, fragments of Purbeck stone (dressed), iron sand, pieces of the hill limestone, old pipes, etc.

character is practically impossible, we may say that the Creechbarrow Beds, as determined from indications near the summit, have a dip to the northwards of from 10° to 12°.

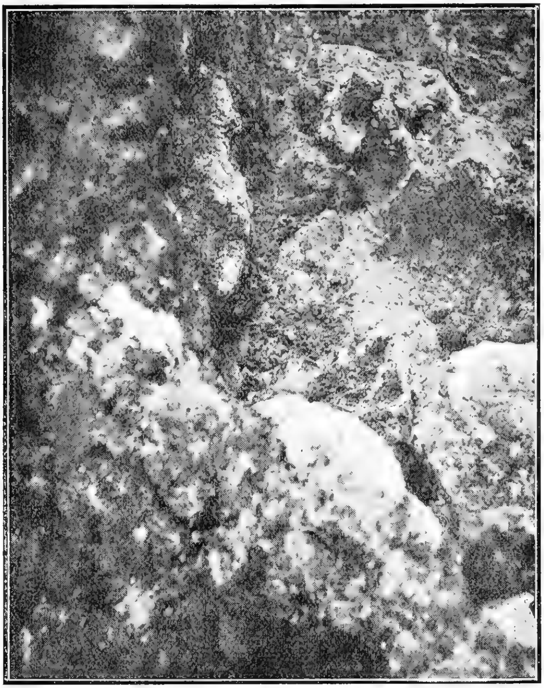
A  B

Fig. 2.—The Summit Pit (No. 5). From a photograph by Mrs. Hudleston.
A. Solid concretionary limestone *in situ.*
B. Artificial rubble, mainly derived from the limestone.

The vertical section as shown in Fig. 2 is about 7 feet.

The summit has been artificially flattened, and certain courses of Purbeck stone (dressed) remain as evidences of the foundations of the Keeper's Lodge which formerly occupied this site. About a foot or eighteen inches below this we came upon a section which is partly natural and partly artificial. The natural portion consists of solid tufaceous limestone, showing certain irregular divisions, but nothing that could be referred to bedding: the jointing is in all directions with possibly a tendency to the vertical. Alongside of this mass of natural limestone is a miscellaneous rubble of artificial origin. The upper portion consists of small calcareous rubble mixed with sand, flints, etc., down to a line of blackearth. Below this is a conglomeration of looser stones, where flints and large blocks of tufaceous limestone may be noted. The whole probably rests on tufaceous limestone *in situ* lower down.

Situated on the very top of Creechbarrow this section is very suggestive. That the summit has been artificially flattened for the purpose of supporting a structure is evident. At what period this was *first of all* done it is impossible to say, but we are justified in supposing that before human interference with such a prominent feature of the landscape, the limestone rock stood out like a needle or tooth above the encompassing greensward. Being too precipitous in its natural state to support a building, masses of the original summit have been cut away and used in forming the strange medley of rubble which is seen on the right of the section. We perceive indeed the very fragments of limestone that have been detached so as to make a platform on which to build. The foundations are thus partly natural and partly artificial.

It is possible from specimens obtained in this pit more especially to form some estimate of the character of this limestone. I hope to treat the subject more fully with appropriate illustrations in the Proceedings of the Dorset Field Club. Meantime, the following rough lithological notes extracted from my field notebook will serve to give an idea of some of the specimens.

2*a*. This is a large fragment of creamy white tufaceous limestone with specs and threads of oxide of manganese in places; flattened pisolitic bodies in brownish calcite are numerous. There are casts of interiors of a shell not unlike *Paludina*. The whole of this fragment has a tufaceous aspect and is free from the buff-coloured patches which characterize a certain group of specimens.

The external surface is rough and in one corner full of curious shapes, which are probably concretionary bodies developed by weathering.

2*b*. A white tufaceous limestone similar to the last. This is pretty full of pisolitic bodies in brown calcite; it moreover contains a peculiar *horse-shoe section* in brown calcite, of which there are indications in so many of the specimens. There are indications of a *Paludina* likewise, but so merged in the matrix as to be indistinct.

2*d*. Similar to the last and containing the indications of a *Paludina* which clearly differs from the ordinary Purbeck species (*P. carinifera* and *P. elongata*).

3*a*. A creamy tufaceous limestone with some buff-coloured patches and specs and threads of manganese oxide. Sections of ordinary pisolites here and there. But this specimen is remarkable for three very large *horse-shoe sections*, which certainly represent concretions in brown calcite, whose origin is by no means clear. These sections show a series of concentric rings with a large hollow in the centre filled with the ordinary matrix. There is no radial structure; one end of the circle is thick, whilst the opposite end thins almost to disappearance. Some of these horse-shoe sections are nearly $1\frac{1}{2}$ inches in diameter.

3*c*. Rather more compact limestone with some buff markings. The chief interest of this specimen is, that it seems to afford a solution of the problem of the horse-shoe sections. There is to be seen here a pisolitic concretion with an interior *like a very small egg*, of which the shell, represented by the brown calcite, is developed so obliquely, that it is quite thick on one side and quite thin on the other side. A section of this gives a shape like a horse-shoe, which evidently belongs to the group of pisolites.

4*a*. Very fine specimen of pisolitic limestone, quite suitable for collections. Cuts well and takes a good polish.

Without special illustration the above may be accepted as a brief lithological description of the Creechbarrow limestone. Recently some better specimens of univalves have been found, and these are free from matrix; but on the other hand they have suffered from an incrusting process which has greatly affected their original form. The *Paludina* appears to be a short variety of *Paludina media*, and the other univalve may possibly be a member of the Melaniadæ.

This limestone forms the summit of Creechbarrow, and it is terminated towards the south by what may be deemed an escarpment (see Fig. 4). We can follow it on the dip towards the north, though its lateral extension east and west of the immediate summit is certainly restricted, but the elongated shape of the summit ridge is undoubtedly determined by this very hard rock. About 120 feet N.N.E. of the summit, in the direction of the dip slope, we sank another pit (No. 6) and came upon a very interesting section. The hard nodular limestone is here found to form a very rough and irregular surface, beneath a peculiar deposit which has a depth of from 3 to 5 feet according to the inequalities of the limestone. About 100 feet from this in a N.N.W. direction, and just within the 600 feet contour, we found this same peculiar deposit, quite 6 feet thick, resting on the irregular surface of the tufaceous limestone, here apparently undergoing a softening process.

The deposit on the Creechbarrow Limestone.—Of the many enigmas which this curious hill presents to the puzzled geologist there are none more difficult to solve than the true nature and origin of the deposit which, from a geological point of view, is the highest in the sequence, although so irregularly distributed that it has not been indicated on the dip slope section (Fig. 3). The upper portion of the deposit, in places, consists of a mass of rounded and subangular flints in a muddy matrix, passing downwards into a stiff yellow clay with much black oxide of manganese, and a variable assortment of large and small flints, flint pebbles, and other stones, disposed after the manner of Drift. At present I must be content to state the facts about this deposit as I find them, without attempting any explanation. It seems probable that in spite of its superficial position this remarkable drift is really part of the Creechbarrow series, and does not in any way represent the Plateau-gravel.

We must now endeavour to trace the limestone (*a*) on the dip slope to the point where it disappears. Omitting any indication of the peculiar deposit mentioned above, Fig. 3 is a rough superficial section from the summit of Creechbarrow (637 feet) to the sand-pit about the 350 feet contour.

The horizontal distance may be 1,150 feet. The northern spur which we follow is in alignment with the longer axis of the hill, which extends N.N.E. from the summit. It must not be supposed that the calcareous beds have been proved every yard of the way. There are two places on this spur, above the 500 feet contour, where 'marl' has been found close to the surface. The highest of these is 250 feet, measured horizontally from the last pit where we found the

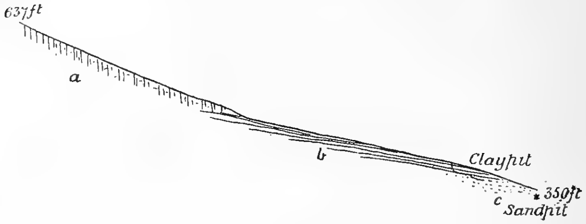


Fig. 3.—The Northern Slope of Creechbarrow.
a. Hill-top, or Creechbarrow limestone. *b*. Brown Clay series.
c. Sands underlying the Brown Clay.

hard hill-top limestone. I should observe that the term 'marl' merely refers to a softened condition of the limestone. There is a well-marked bluff about the 500 feet contour, near where the calcareous series terminates, and the following section, derived from a series of trenches which we made in the hill-side, shows the nature of the Creechbarrow series at this point. The top of the section just reaches the 500 feet contour.

Northern Section.

	ft.	in.
a. Surface with tree roots, etc.	3	0
b. Fine clayey sands with flints	2	0
c. Sandy without flints	2	6
d. Tough yellow clay	2	0
e. Upper marl	1	0
f. Tough clay	2	6
g. Main marl	7	0
N.B.—There is a break here owing to old workings, which would add to the marl ...	5	0 ?
h. Impure marl containing sand—a passage bed ...	3	3
i. Buff clayey sand	1	6
j. Flint gravel and sand	1	3
Total section	31	0

This series of beds rests upon a buff-coloured clay.

(*b*) Is a very extensive and important deposit, the thickness of which it is not easy to estimate. It can hardly be less than 40 feet thick and may be more, and constitutes an important feature along the north side of the hill on both sides of the 400 feet contour. In the brickearth are said to be lenticular masses of sand with flints at the bottom, which to a certain extent detracts from its value for brick and tile making. The brown clay series, in which Mr. Bond's clay-pit and brickyard are situated, rests on sands (*c*) which may be well studied at the 'Sand-pit.'

Returning for a moment to the limestone (*a*), it is evident that the face, or bluff, so well marked in the 'Northern Section' is not a natural one: everything has the appearance of an extensive open working, presumably for 'marl,' yet there is no tradition as to any working here, consequently the period must have been sufficiently remote. The continuation of this face westwards, usually near the 500 feet contour, also has an artificial look about it indicative of former workings. One of the most peculiar circumstances in connection with this case is the total absence of any limestone fragments throughout this long line of presumed old workings. The same remark must also be made as to Creechbarrow generally. Had any limestone fragments been found rolling about, the discovery of the limestone must inevitably have followed. I have searched also in old walls and houses for any trace of this limestone, without success. Where stone has been used in these buildings it seems in all cases to be Purbeck stone. Consequently we are faced with the fact that while flints of the Creechbarrow series abound and are characteristic, no single specimen of the Creechbarrow limestone appears on the surface. Rapid disintegration when exposed to the atmosphere can be the only explanation, though in view of the excessive toughness of the hill-top limestone this seems all the more extraordinary. There certainly are some peculiarities in these concretionary limestones which we do not fully understand. I mentioned before that in the talus near the summit the limestone was already softened to the consistence of chalk, and now we perceive that in the course of its further descent it passes away altogether as a distinct rock.

III. Inferences.

There are many points yet to be considered in connection with Creechbarrow, but the facts detailed in the preceding pages must suffice at present for a communication which is essentially preliminary. The great problem of all, viz., the stratigraphical relation between the Creechbarrow Beds and the Pipeclay series of recognized Bagshot age, is as yet uncertain. This is a matter of local interest, requiring special illustration in the way of plans, etc., which I hope to bring forward in the Proceedings of the Dorset Field Club. It is certain that the Creechbarrow Beds press the Pipeclay series towards the N.N.E., or, in other words, they are said to 'bulge' them. This circumstance is in favour of their being of Bagshot age, and on a lower horizon than the Pipeclay series. On the other hand, the occurrence of limestone in the Bagshots is, so far as I am aware, a phenomenon hitherto unknown in England. Moreover, there is a certain degree of analogy between the Bembridge limestone and the Creechbarrow limestone, which at least renders it possible that the latter may really belong to an Oligocene series. Hitherto it has been a matter of exceeding difficulty to ascertain what are the stratigraphical relations of the Creechbarrow Beds to the Pipeclay series. If the Creechbarrow Beds are of Oligocene age, then there is no great difficulty in supposing that they simply overlie the whole Bagshot series and are cut off on the north. But if they are of Bagshot age, as I consider most probable, they must pass under the Pipeclay series, or in some unexplained manner abut against them.

It should be borne in mind that the whole development of the Creechbarrow Beds is totally different to the Pipeclay series of the Bagshots. The following points are among the differences as shown in the Creechbarrow Beds: we have a concretionary pisolitic limestone of fresh-water origin, an abundance of large flints and other coarse detritus in intimate association with fine yellow clay and sands (I am informed that no flints are found in the Pipeclay beds). There is also a considerable amount of oxide of manganese, especially in the mechanical sediments, and the occurrence of botryoidal nodules of this mineral is noted in some of the sands. Plant-remains and carbonaceous matter are also rare. On the other hand, the Pipeclay series is remarkable for the complete absence of calcareous matter, the excessive fineness of its sediments, the large development of pale clays with admixture of stained or 'bloodshot' clays, and the abundance of carbonaceous matter, sometimes with plant impressions and remains.

One point of considerable importance, which can only be brought out fully with the aid of a sketch-map, consists in the fact that, whereas immediately to the east of Creech Farm the Pipeclay series is found almost in contact with the London Clay and so continues all the way to the gap at Corfe Castle, yet *to the west* of this line, in the vicinity of Creechbarrow itself, we find that a distance of several hundred yards separates the Lower Tertiaries from the Pipeclay, the intervening space being occupied by the Creechbarrow Beds. At present I can only state the fact without offering an adequate explanation. We can scarcely believe that the whole Creechbarrow series has been faulted out in the area where it is missing, and thus we must fall back on the theory of exceptional development within a limited area if we adopt the Bagshot age of this very peculiar set of beds. We know from Mr. Clement Reid's memoir that the Bagshot Beds west of a certain meridian in the county develop into exceedingly coarse sediments, but there is nothing of this kind in Purbeck, excepting the Creechbarrow Beds themselves, which are only of limited extent.

Let us now see how this investigation bears on my three theories as to the origin of the hill itself. Practically these were: (1) original peculiarity of deposit, (2) exceptional tectonic disturbance, (3) protection afforded by Plateau-gravel.

Of these three the first is nearest the mark, and the third may be entirely dismissed. The whole area has, of course, been greatly affected by tectonic disturbance, but it is doubtful at present whether anything exceptional of this nature has contributed to the formation of this peculiar feature of the landscape.

The accompanying section will serve to show the relation of the mass formed by the Creechbarrow Beds to the Lower Tertiaries (London Clay and Reading Beds) and the Chalk. One important point to bear in mind is that the neck of land, consisting of Lower Tertiaries, which connects Creechbarrow with the Chalk, has an elevation of 500 feet, whereas the Lower Tertiaries along the dip slope of the Purbeck Hill elsewhere rarely attain an elevation of 300 feet (see Fig. 1 for confirmation of this). Hence, the agency which protected the Creechbarrow Beds protected the Lower Tertiaries to a certain extent. I cannot doubt that this agency was the hard concretionary limestone which now constitutes the summit of Creechbarrow itself, and which in all probability extended considerably further in a direction opposite to the dip after the manner of escarpments generally.

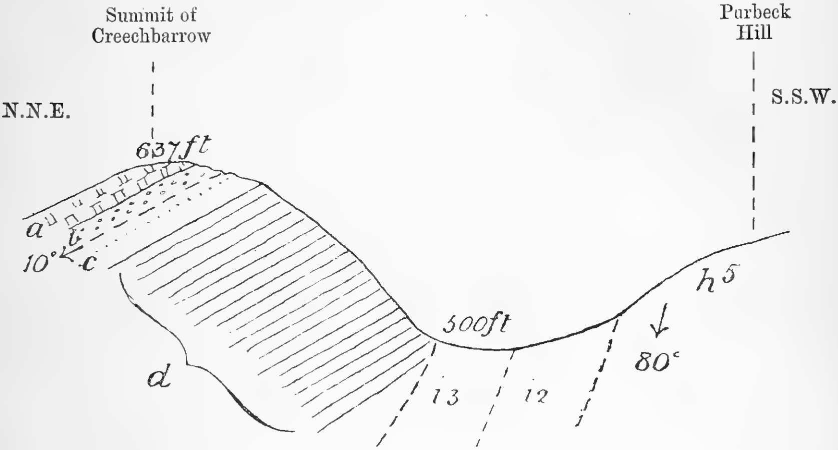


Fig. 4.—Generalized section of Creechbarrow (south side).
a–d. Creechbarrow Beds. *a.* The hill-top limestone. *b.* Sands with calcareous concretions. ← Bed of flints. *c.* Sands below the flint-bed. *d.* Beds not specially determined, mostly sandy. (See section-page.)
i^3. London Clay. i^2. Reading Beds. h^5. Chalk.

Whether the Creechbarrow Beds are really unconformable to the Lower Tertiaries, as shown in the diagram, I am unable to say. Also the angle of dip of these beds is only obtained by inference. The high dip of the Lower Tertiaries shown in the diagram is based on the three following considerations: (1) on the narrowness of the outcrop, (2) on a dip of 80° towards the north which is seen in the adjacent chalk-pit, and (3) on the fact that one of the ironstone-grits of the Reading Beds is seen in a vertical position about $\frac{3}{4}$ mile to the eastward of the section. With reference to the Creechbarrow Beds themselves, a dip of from 10° to 12° is obtained from observation for the topmost series,[1] but the actual dip of the lower beds, in immediate contact with the London Clay, as also their true stratigraphical relations, can only be a matter of inference.

The primary object of this investigation has been an endeavour to explain the causes which have led to the formation of such an exceptional feature in the landscape of the Isle of Purbeck as Creechbarrow, certainly the most noteworthy hill composed

[1] See p. 248.

exclusively of Tertiary beds in all England. It was originally represented by the Geological Survey as being held up in a forked fault with a sort of repetition of the London Clay at its northern base. There certainly seems no justification for the introduction of the London Clay into this position, viz. the northern base of the hill. There may, however, be some better reason for the introduction of a fault, for it is just hereabouts that the junction of the Creechbarrow Beds with the Pipeclay series takes place. This is a piece of stratigraphy which I have not yet succeeded in solving to my own satisfaction, though such a question has only an indirect bearing on the origin of Creechbarrow as a hill. I am far from saying that everything in connection with its origin has been explained, but without doubt one great predisposing cause is the protection which the softer strata have received from the concretionary limestone. Such protection is not only accountable, in a great measure, for the existence of the hill itself, but also for its present shape, which has to a considerable extent been determined by the original form of the calcareous body that accumulated in some old Tertiary lakelet, ages before the uplift of the Purbeck Hills.

II.—Woodwardian Museum Notes: Salter's Undescribed Species. VIII.[1]

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

(PLATE XVI.)

LAMELLIBRANCHIATA (Continued).

Goniophora grandis, Salter. (Pl. XVI, Figs. 1, 2.)

1873. *Goniophora grandis*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 151 (*a* 827).

1891. *Goniophora grandis*, Woods: Cat. Type Foss. Woodw. Mus., p. 77.

There is only the one poorly preserved and imperfect specimen in the Woodwardian Museum on which Salter founded this species. It comes from the Wenlock Limestone of Dudley and belongs to the Fletcher Collection. Salter says of it (*a* 827): "Strongly costated and marked with lines of growth which decussate the ribs. Twice the size of the common Ludlow species." The material is so poor that the specific description must necessarily be incomplete.

Diagnosis.—Shell narrow, transversely elongate, dorso-ventrally compressed. Valves very deep, angulated by diagonal, very strong carina from beak to posterior angle. Anterior side with large deep subcordate lunule. Below the diagonal carina the surface of the valves is marked by about twelve strong radiating rounded ribs, curved slightly forwards, parallel to the margins of the lunule and crossed by numerous concentric growth-ridges. Above the carina the sole ornamentation is the continuation of this series of concentric ridges, the radiating ribs being entirely absent.

Measurement.—Length (diagonal, along carina) approximately 45–50 mm.

[1] For previous articles see Geol. Mag., 1901, pp. 5, 106, 246, 355, and 576; 1902, pp. 122 and 145.

Remarks.—It is not very profitable to compare this poorly defined species with others. The only form of *Goniophora* known to me with similar radiating ribs on the anterior lower half of the shell only and concentric ridges above and below the carina, is *G. truncata*, Hall,[1] from the Hamilton Group of New York.

Modiolopsis complanata (Sow.).

1851. *Modiolopsis complanata* (Sow.), McCoy: Brit. Pal. Foss., p. 266.
1873. *Modiolopsis planata*, Salter: Cat. Cam. Sil. Foss., p. 182 (*b* 71–3).
1891. *Modiolopsis planata*, Woods: Cat. Type Foss. Woodw. Mus., p. 81.

The specimens which McCoy named and described (op. cit. supra) as *M. complanata* (Sow.) were renamed *M. planata* by Salter, though in the margin of his Catalogue (loc. cit.) he puts *M. complanata* with a query after it. I do not see sufficient reason to doubt the accuracy of McCoy's identification, and therefore Salter's specific name *planata* must be dropped.

Modiolopsis mimus, Salter. (Pl. XVI, Fig. 3.)

1873. *Mytilus mimus*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 182 (*b* 141).
1891. *Mytilus minimus*, Woods: Cat. Type Foss. Woodw. Mus., p. 82.

The name of this species is printed *mimus* in Salter's Catalogue, both on p. 182 and in the index, p. 200. On the back of the tablet bearing the specimen the name *minimus* was found written in pencil, and Mr. Woods adopted this in his Catalogue. There is only one specimen of the left valve (*b* 141), and it comes from the Upper Ludlow of Lesmahagow.

Diagnosis. — Shell inequilateral, obliquely elongate, obtusely pointed. Body narrow, slightly curved, convex, especially near beak. Beak anterior, terminal, small, pointed, convex. Posterior portion of shell rather depressed and flattened, but not sharply marked off from body of shell. Ventral margin short, subacuminate. Posterior margin almost vertical, gently rounded. Hinge-line straight, nearly the width of shell, at angle of 60° to oblique axis.

Surface marked with concentric growth-lines.

Measurements.

	mm.
Length along oblique axis	16
Width along hinge-line	9
Length from hinge-line to ventral margin	12

Remarks.—This species bears some resemblance to the Bala form *Modiolopsis pyrus*, Salter,[2] but the hinge-line is relatively rather longer, the beak more acuminate and terminal, and the posterior portion of the shell larger. Some American species of *Leptodesma* from the Chemung Group[3] seem to bear a considerable resemblance to *M. mimus*.

Orthonota (?) Hughesi, Salter. (Pl. XVI, Figs. 4, 5.)

1873. *Ctenodonta Hughesi*, n.sp., Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 82 (*a* 979).
1891. *Ctenodonta Hughesi*, Woods: Cat. Type Foss. Woodw. Mus., p. 74.

[1] Hall: Palæont. N.Y., vol. v (1883), p. 13, pl. xliv, figs. 1–5.
[2] Mem. Geol. Surv., vol. iii, 2nd ed. (1881), p. 552, woodcut xii, fig. 1.
[3] Hall: Pal. N.Y., vol. v, pt. 1, pl. xci, figs. 23–5.

Salter says of this form that it is "squarer and more ovate than the kindred Caradoc forms." There are four specimens in the Woodwardian Museum, and Salter based his species on two of them (*a* 979) consisting of a complete internal cast of both valves and an external cast of the upper portion of the shell. All were found in the Lower Llandovery Beds (Upper Bala of Salter) of Sefin Llettyrhyddod, Llandovery.

Diagnosis.—Shell equivalve, inequilateral, transversely subovate, narrowing and subtruncate posteriorly, subcompressed. Beaks obtuse, moderate, near anterior end, with small impressed lunule in front below them. Hinge straight, about two-thirds width of shell. Anterior portion of shell convex; posterior portion slightly flattened, compressed. Anterior end broadly rounded; posterior end narrower, more pointed, angulated between ridges. Ventral margin regular, subparallel to dorsal. Two faint low diverging ridges run obliquely backwards over posterior slope of valves to posterior end of ventral margin, but are almost indistinguishable near the beak. Hinge area behind beaks narrow, lanceolate. Ligament external, in groove. Hinge-line edentulous? Pallial line simple, no sinus. Posterior adductor scar well marked, about half-way between beak and posterior extremity. Anterior scar faint. Surface of valves marked by faint concentric growth-lines.

Measurements.

	mm.
Length	15
Width	24
Thickness	8

Remarks.—The characters of the hinge and absence of the typical teeth would alone be sufficient to remove this species from the genus *Ctenodonta*; and it appears to belong to the genus *Orthonota*.

Orthonota solenoides (Sow.) [1] bears a distant resemblance, but is relatively more transverse, and the posterior ridges are wanting.

ACTINOZOA.

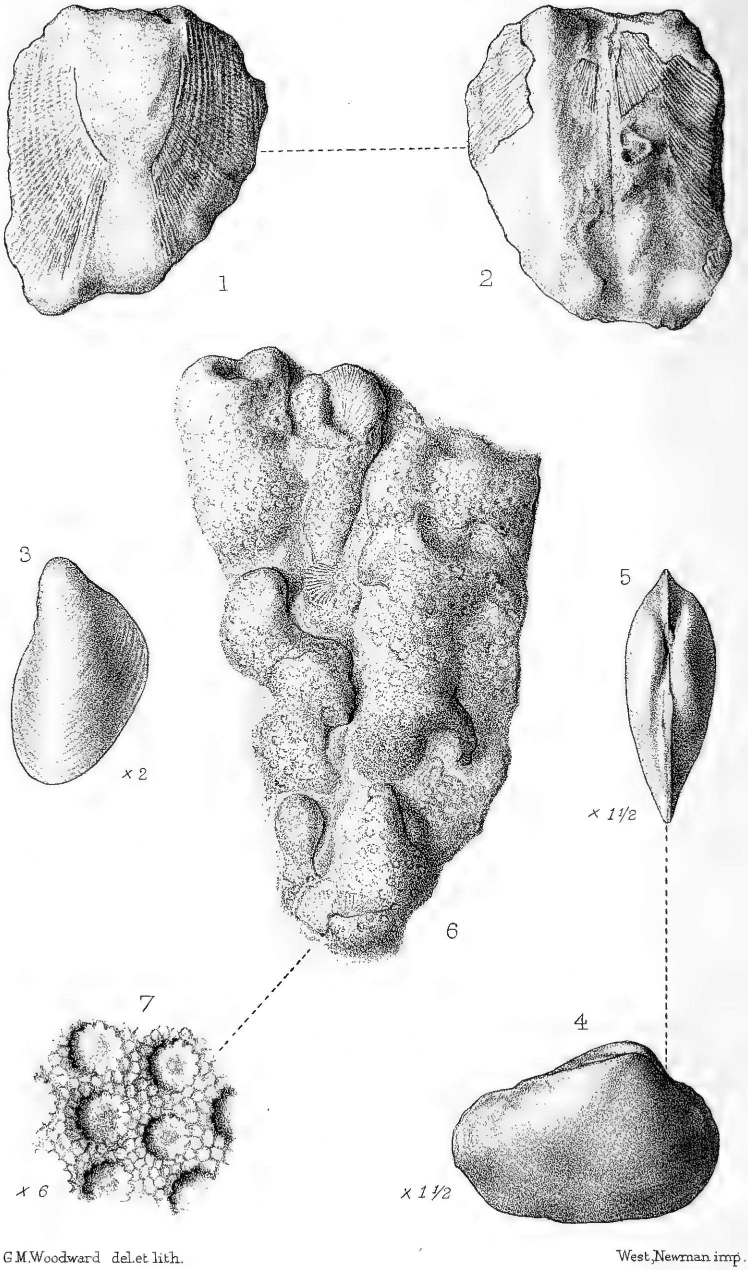
Heliolites cæspitosa, Salter. (Pl. XVI, Figs. 6, 7.)

1873. *Heliolites cæspitosa*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 104 (*a* 343).
1888. *Heliolites cæspitosa*, Etheridge: Cat. Brit. Foss., pt. i (Palæoz.), p. 20.
1891. *Heliolites cæspitosa*, Woods: Cat. Type Foss. Woodw. Mus., p. 20.

The three original specimens (*a* 343) come from the Wenlock Limestone of Dudley and belong to the Fletcher Collection. The species is not uncommon there, and we have numerous specimens from the same locality. Salter (op. cit. supra) describes it as "something like *H. Grayi*, but cells approximate; shallow pits, not raised." One of the original specimens is a fine and almost perfect corallum.

Diagnosis.—Corallum ramose, but not diffuse, consisting of several subparallel, irregularly rounded or lobate, stout branches, increasing in thickness from the base, and bearing calices over their whole surface. Larger corallites small, very numerous, approximate,

[1] Murchison Siluria, 5th ed., 1872, pl. xxiii, fig. 9.



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

Silurian Mollusca & Coral.

usually less than half their diameter apart, in some cases almost contiguous; margin slightly exsert, but calyx sunk below general surface; walls crenulated and infolded to form twelve short septa, extending inwards from one-quarter to one-third the diameter of the calyx. Smaller corallites (cœnenchyma) not numerous, usually only 2–4 irregular rows between the larger corallites; polygonal in shape, with well-developed walls and regular horizontal and mostly equidistant tabulæ, so as to divide the tubes into a series of square cells.

MEASUREMENTS.

	mm.
Diameter of calyx of larger corallite	1–1·5
Length of corallum...	80·0
Diameter of corallum at base	20·0
Diameter of corallum at crown	55·0

REMARKS.—This species differs from *H. Grayi*[1] in the rounded or lobate form of the branches, and in the number, approximation, and depression of the calices of the larger corallites. From *H. inordinata* it differs by possessing stouter, more lobate branches, more numerous, closer and larger corallites with depressed calices, and less abundant cœnenchyma. A Norwegian species named *Plasmopora ramosa*, Kiär, has been recently described[2] which bears a considerable resemblance to *H. cæspitosa*, and is stated to be closely allied to *H. Grayi*. It differs in the more exsert margins of the corallites, the absence of septal prominences, and in the wider spaces between the corallites. The internal structure, moreover, which is the most important feature, appears to be distinct.

EXPLANATION OF PLATE XVI.

FIGS. 1, 2.—*Goniophora grandis*, Salter. Wenlock Limestone: Dudley. Fletcher Coll. Nat. size.

FIG. 3.—*Modiolopsis mimus*, Salter. Upper Ludlow: Lesmahagow. Enlarged $\frac{2}{1}$ nat. size.

FIGS. 4, 5.—*Orthonota Hughesi*, Salter. Lower Llandovery Beds (Upper Bala, Salter): Sefin Llettyrhyddod, Llandovery. Fig. 4, side view; Fig. 5, hinge aspect of shell. Enlarged $1\frac{1}{2}$ nat. size.

FIG. 6.—*Heliolites cæspitosa*, Salter. Wenlock Limestone: Dudley. Fletcher Coll.

FIG. 7.—Portion of corallum, enlarged $\frac{6}{1}$ nat. size.

III.—ON THE MAKING OF A QUARTZ SCHIST.

By JOHN PARKINSON, F.G.S.

IN a paper published[3] some eight years ago, Prof. T. G. Bonney discriminated between the dominant characteristics of quartz schists from the Alps and quartzites modified by pressure. The distinctions as therein pointed out may be thus summed up.

In a quartz schist we find an absence of indications of original fragments, the shape of the quartzes proving that they were formed *in sitû*; together with no evidence "that the mica in its present form is derivative"; from which it almost necessarily follows that

[1] Edwards & Haime: Brit. Foss. Corals (Palæont. Soc.), p. 252, pl. lviii, fig. 1.

[2] Kiär: Die Korallenfaun, Ét. 5, Norweg. Silur., p. 32, t. v, figs. 5–6: Palæontographica, Bd. xlvii, 1899–1900.

[3] GEOL. MAG., Dec. III, Vol. X (1893), p. 204; also GEOL. MAG., Dec. IV, Vol. III (1896), p. 400 ("On a Pebbly Quartz-Schist from the Val d'Anniviers").

the origin of the rock is "a matter of conjecture" rather than of proof (p. 209, etc.). In a quartzite the contrary holds. The clastic origin of the quartzes is obvious, and the form and mode of occurrence of the mica shows it to be detrital; hence the characters separating normal types of the two groups of rock are clear enough in a thin section, if not in a hand-specimen.

The rocks which form part of the subject of the present communication were collected from the neighbourhood of the Illecellewaet Glacier in the Selkirk Mountains; and microscopically present a structure intermediate between that of a quartz schist and that of a quartzite.[1]

Since the gap which separates these two rock types is one which is seldom bridged, I venture to think it may be profitable—(1) to consider the changes which have taken place in the North American rocks which will be referred to as quartz felspar grits; (2) to compare the latter with some of the older quartzites of India, which present indications of change of a rather different kind; and (3) to see what help the whole affords in elucidating the difficult problem—the making of a quartz schist.

1. The Quartz Felspar Grits.[2]

These form a group of rocks exhibiting slight variations in degree of coarseness and manner of fracture, commonly speckled with obvious grains of felspar and quartz; although the sheen surfaces, formed through the development of secondary mica, record the pressure which the rock has undergone. In a few localities, e.g. the moraine of the Illecellewaet Glacier, elongated ellipsoidal spots are conspicuous, exhibiting a parallel arrangement, and which average in size ·5 in. × ·15 in. × ·05 in. As seen in a thin section they consist of very irregular grains of calcite, outlined by an iron staining, which straggle through the other constituents instead of forming a clearly defined patch. These may possibly be the remains of worm burrows distorted by pressure.

[1] See also a paper by Professor T. G. Bonney in Quart. Journ. Geol. Soc., 1888, vol. xliv, p. 32, on the Huronian Series in the neighbourhood of Sudbury (Canada); a sedimentary series showing changes which approximate them in character to a true schist. I am greatly indebted to Professor Bonney for opportunity to study his slides of these rocks, and for suggestions given from time to time on this and kindred subjects.

[2] The age of these rocks is a matter of interest. The identification is a rather difficult one, and I am indebted to Dr. Whiteaves and Dr. H. M. Ami, of the Canadian Geological Survey, for kindly replying to my question on the subject. To the E.N.E. of, and about eighteen miles as the crow flies from, the Illecellewaet Glacier, a Lower Cambrian fauna has been found, and to the westward lies the Shuswap Series, probably of Archæan age. Above the latter and to the east are "dark argillites passing into micaceous schists" (Summary Rep. 1890–1, n.s., v, pt. 1, p. 20A). These are the Nisconlith Series (Lower Cambrian), probably equivalent to the Bow River Series. See also papers by the late Dr. G. M. Dawson, Bull. Geol. Soc. Amer., vol. ii, pp. 165–176, "Note on the Geological Structure of the Selkirk Range," and Ann. Rep. Geol. Surv. Canada, 1896, vol. vii, pt. B, pp. 28B–34B, in which the quartzites in the vicinity of the Glacier House, Mountain Sir Donald, etc., are placed in the Cambrian system under the name of the Selkirk Series and overlying the Nisconlith Series.

The remnants of original mineral grains are conspicuous in most of the thin sections. The presence of felspar, both orthoclase and plagioclase, together with quartz, indicate either a quartz felspar grit or a quartz felsite. The great preponderance of quartz and the very clastic appearance of the felspars clearly point to the former rock; in fact, in many instances the names of quartzite and quartz felspar grit are still applicable, in spite of considerable mineralogical and structural modifications.

The condition of the felpars is the most interesting feature. Mineralogical change is made manifest by a cloudiness in the interior of the crystal, due to the presence of innumerable minute scales, flakes, or prisms of a mineral which, no doubt, is a mica. Towards the periphery of the crystal the latter pass into a fringe of well-formed flakes intermingled with grains of quartz, the character of the former being identical with that of the typical quartz schists of the Alps. Occasionally a system of lines of greater change, and probably of incipient fracture, traverses the crystal, and is marked by closely aggregated scales and flakes of mica. At the same time crush shadows form, followed in due course by fracture and loss of uniform polarization; while, frequently, more or less clear spots appear representing developing individuals of quartz or secondary felspar; the outcome being complete disintegration and reconstitution.

Some of the larger quartz crystals have exceedingly irregular edges and exhibit undulose extinction; and in the smaller grains a similarity of size and of polarization tints is often characteristic, together with some elongation in the direction of foliation. In a more advanced stage of reconstruction a more marked parallelism exists between the flakes of mica. While these are for the most part spread through the rock in thin and irregular bands, they are also embedded in the quartz grains, or wedged between their edges, and have even trespassed the boundary between two individuals. In some sections they reach ·009 inch in length. The presence of a mica flake in the centre of a quartz grain, which is large in proportion to it, and situated near a system of fine cracks by which this grain is traversed, indicates the passage of the mica substance in solution by capillary action. The cracks contain specks of a mineral (about ·0025 inch across) which may be referred to mica. Now and then such flakes appear where no obvious cracks exist, and occasionally a long thin wedge of mica flakes penetrates the quartz grain. The condition of the mica is different to that of the mineral produced by the mere crushing of a quartz felspar grit; the distinction consisting in this, that in the rocks under consideration the mica forms definite flakes usually bounded by definite lines, whereas simple crushing produces a matted intergrowth of film-like scales which ordinary powers and ordinary thin sections fail to resolve into its components. The smaller quartz grains—commonly ·004 to ·009 inch across—possess angular or subangular outlines, are not conspicuously elongated at right angles to the direction of pressure, and do not exhibit undulose extinction to any noticeable degree. Hence the strain produced by the pressure the rock has undergone has been removed from the greater part of the rock, while the larger and obviously clastic grains still bear its marks.

The rock does not appear to have undergone serious deformation since it assumed its present condition, and as regards the state of the quartzes at the time of maximum pressure we are met with evidence of two and diverse kinds. Firstly, we find clear indications of incipient cracks, conical in section but with slightly concave outlines, which are usually characteristic of mineral matter stressed beyond its elastic limit, and pointing to the crushing of a practically rigid solid; whereas, secondly, the irregular shape of the quartzes under the microscope are suggestive of a plastic deformation, e.g. some have been apparently bulged out by an intruding finger of the rock, or the like.

On the whole I conclude that the constituents of the rock have been partially plastic under the stress to which they have been subjected, but at the same time sufficiently rigid to have cracked in the process.

With the assumption of these characters disappears the smashed-looking aggregate so universally indicative of crush. The mica clearly has been formed *in sitû*, and the production of the quartz mosaic by crushing and subsequent reconstitution could not be safely predicated simply from an examination of this part of the section. The grains of felspar scattered throughout the slide are plentifully sprinkled by minute crystals of mica, or slightly discoloured by brownish dust, but otherwise are quite translucent, and show well-defined polysynthetic twinning (12° to 15°). We find, then, almost a new rock; the traces of original quartz grains are few in number; the mica has been formed *in sitû* and does not suggest a clastic origin; and the greater proportion of the felspars have undergone reconstruction.

2. The Quartzites of Delhi and Jaipur.

Of great antiquity [1] and greatly altered, the old quartzites of India near Delhi and Jaipur yet show no resemblance to the rocks above described. A specimen taken from the celebrated 'Ridge' at Delhi consists of quartz and thickly scattered, exceedingly small crystals of various minerals. The most common of these are shapeless flakes and scales of a quite colourless mica, averaging roughly ·003 inch across, distributed without any orientation through the rock, commonly at the junction of two or more quartzes. Indications of the basal cleavage are usually wanting, and there is no evidence that the mineral is detrital. In addition, we find flakes of a gummy brown to greenish brown tourmaline (and possibly some of brown mica), many of which are exceedingly minute, often not more than ·0006 inch in diameter, and which usually exhibit rounded outlines, especially in the smaller grains. Other constituents occur, but are

[1] They are a member of the transition system, i.e. they occupy an intermediate position between the gneisses and the older Palæozoic rocks.

not easy to identify, including, however, calcite, zircon, specular iron, and pyrites. Between crossed nicols we realize the shapelessness of the quartz grains, which interlock the one with the other as irregular polygons without any trace of an orientation. They average ·019 inch across. A slice taken from the very similar quartzite of the Kutub, 11 miles south of Delhi, possesses less white mica and associated minerals, and the quartzes are dustier and exhibit outlines still more fantastically irregular.

As in the preceding slide, although we find indications of undulose extinction, this is the only sign of pressure, so that any crushing of the grains which may have occurred has been almost entirely obliterated. Now and then, indeed, we seem able to recognize that the longer axes of the grains have a common direction; but the haphazard cross-sections show outlines sometimes almost of a horseshoe shape with waved edges, at others elongated with many irregular projections. The quartzes contain many rounded spots of felspar; these are unstriped, rather opaque, and often roughly rectangular in section, exhibiting then an obscure orientation. So far as it goes this last-named feature indicates rearrangement *in sitû.* An average size is ·008 × ·003 inch. A few brown zircon prisms and some crystals of magnetite are found. A specimen from the top of the ascent to Ambér from Jaipur also contains felspar fragments, in many of which polysynthetic twinning (extinction 15°) is still discernible, but which also occur as rounded grains included in a quartz crystal, and often are better defined than happens in the preceding slide.

The quartz contains rows of inclusions and gas cavities which have a common direction and occasionally extend without interruption from one grain to another. Strain shadows are inconspicuous, but the parallel lines of inclusions indicate that the rock has been subjected to a certain degree of pressure. The felspars, however, appear not to have suffered in the least, and we find no attempt to break up into mica and quartz. The slide contains also grains of bluish-green tourmaline up to ·016 inch in length, magnetite, zircon, and a few elongated flakes of a green mica.

These rocks form a group usually possessing a saccharoidal lustre and close-grained texture, and are distinguished microscopically by the absence of evidence of pressure and by the irregular outline of the quartz grains. These outlines must naturally have been acquired *in sitû,* the structure of the whole proving great alteration.

Conclusions.

The recent researches of Messrs. Adams and Nicolson on the 'Flow of Marble'[1] are of considerable interest in the present enquiry.

In these experiments stumpy columns[2] of Carrara marble were enclosed in tightly encasing jackets made of a material possessing

[1] "An Experimental Investigation into the Flow of Marble": Phil. Trans., 1901, vol. 195 A, p. 363.

[2] An inch or rather less in diameter and about 1·5 inches in length.

a high elastic limit and considerable ductility. The marble, which alone was subjected to pressure, was shorter than its casing, and was squeezed by means of plugs passing into the ends of the jacket; pressure being continued until the bulging of the latter was carried almost to the point of rupture. The rock was squeezed under three sets of conditions—in the first at normal temperature and dryness; in the second heated to 300°–400° C.; and in the third permeated by water vapour at a pressure of 460 lbs. per square inch, the heating being the same as in the second series. The following results appear significant.

1. The crushing load of the deformed marble of the first series was considerably less than that of the natural rock; due, it is thought, to the production of 'cataclastic structure' along certain lines; in the second series the crushing loads were nearly equal, and in the third series that of the deformed rock was at least equal[1] to that of the natural. Messrs. Adams and Nicolson remark that in these experiments the presence of water was not observed to exert any influence.

The absence of cataclastic structure in series two and three and the high crushing load of the deformed rock indicate that the constituent grains of the marble have suffered no loss of elasticity, but that the conditions were such as to allow different molecular groupings as the pressure increased.

2. The experimenters conclude that under the second and third sets of conditions the marble "has not been crushed in the ordinary sense of the term," but that deformation has been principally produced by slipping on the gliding planes of the component crystals.

3. The shape and character of the grains thus produced closely resemble those of a schist.

In accord with these results is the conclusion reached by Messrs. Ewing and Rosenhain[2] in describing the deformation of certain metals, that "each crystalline grain changes its shape through slips occurring within itself, and its position through slips occurring in other grains"; and they point out elsewhere[3] that, if the adaptability of the grains to accommodate themselves to the increasing pressure by this means is insufficient they will be "driven into and through one another"; a result readily conceivable in the case of such a material as lead, but which, in the widely different substances usually considered by the geologist, seems to require something more than mere pressure.

The 'Upper Slate Member' of the Penokee Iron-bearing rocks (Huronian) described by Irving and Van Hise[4] is a case where the work of pressure appears to have been reduced to a minimum. Here we have the production of a new rock from a greywacké, a quartz or mica schist in which no trace of a clastic origin remains.

[1] Sufficient experiments were not made to determine this point.
[2] Proc. Roy. Soc., 1899, vol. lxv, p. 90.
[3] In an experiment on "the effect of very severe strain on lead": Phil. Trans., 1901, vol. 195 A, p. 285.
[4] U.S. Geol. Surv. Monographs, xix, 1892, p. 296.

Van Hise concluded, moreover, that the heat produced by any superincumbent mass of strata, i.e. mere burying, is inadequate to produce the results observed.

That the conditions imposed on the marble by Messrs. Adams and Nicolson may be imitated in Nature with sufficient nearness to produce closely similar results, may be taken as established; but it does not follow necessarily that such conditions imposed upon a quartzite would result in the production of a quartz schist. The pronounced cleavage, the habit of twinning, and the softness of calcite allow of a comparatively easy adaptation to altered circumstances; hence marble no doubt readily shows the effects of pressure and heat.

Not only so, but we have frequently to deal in Nature with a rock which instead of being a homogeneous aggregate of grains consists of two or more minerals, the physical properties of which are very different. Apply to such great pressure, accompany it by heat, and limit freedom of movement, then we should expect greatest plasticity to be found in that constituent whose point of fusibility was most nearly approached; and rupture, in varying degree, in the remainder. Since a quartzite or a quartz felspar grit is an obdurate rock, we must infer pressure and temperature to be increased beyond the limits assigned them in Messrs. Adams and Nicolson's experiments, if similar results are to be produced. A cataclastic structure is not a characteristic of a true schist; hence we must rely on heat, and heat plus water, to play the greater part in the reconstruction; while to pressure may be imputed the flattening of the individual grains and the foliation.

In the Delhi quartzites we appear to possess an example of the work of the two former agents, in the Canadian grits of all three combined.

IV.—A Vindication of Bacon, Huxley, Darwin, and Lyell.

By Arthur R. Hunt, M.A., F.L.S., F.G.S.

The recent attempt I have made to show that the absolutely unanimous adverse criticism of Dean Buckland has arisen from a misapprehension of the facts of the case, has led me to enquire further whether the same cause may not account for far more important results in other similar cases, e.g., the attacks of Huxley on Bacon; of Lord Kelvin on Huxley; and of Lord Kelvin and Professor Sollas on Lyell: attacks which cannot fail to lead the unlearned to believe, not that the critics are right, but that all are wrong together, and unworthy of attention.

Having been geologically educated from first to last on the principles of Bacon and Lyell, I have been genuinely mystified by the intense aversion of Huxley to Bacon, as evidenced by a remark made in 1878: "I have been oppressed by the humbug of the 'Baconian induction' all my life, and at last the worm has turned." Now, if ever there was a genuine Baconian it was Huxley himself, as the following extracts taken in order of succession from Bacon's "Novum Organum" will suffice to prove:—

"Experience is by far the best demonstration, provided it adhere to the experiment actually made."

"We must first, by every kind of experiment, elicit the discovery of Causes and true Axioms, and seek for Experiments which may afford light rather than profit. Axioms, when rightly investigated and established, prepare us not for a limited but abundant Practice, and bring in their train whole troops of Effects."

"Fruits and Effects are the sureties and vouchers, as it were, for the Truth of Philosophy."

"Let no one expect any great progress in the Sciences, unless Natural Philosophy be applied to particular sciences, and particular sciences again referred back to Natural Philosophy."

"The Reverence for Antiquity and the authority of men . . . . and general unanimity, have retarded men from advancing in Science, and almost enchanted them."

"Truth is rightly named the daughter of Time, not of Authority."

"Natural Philosophy has, in every age, met with a troublesome and difficult opponent: I mean Superstition."

"In these mixtures of Divinity and Philosophy the *received* doctrines of the latter are alone included, and any novelty, even though it be an improvement, scarcely escapes banishment and extermination."

"In short, you may find all access to any species of Philosophy, however pure, intercepted by the ignorance of Divines."

"In the habits and regulations of . . . Universities . . . everything is found to be opposed to the progress of the Sciences . . . anything out of the common track can scarcely enter the thoughts and contemplation of the mind."

"In forming our axioms from Induction, we must examine and try, whether the axiom we derive be only fitted and calculated for the particular instances from which it is deduced, or whether it be more extensive and general. If it be the latter we must observe, whether it confirm its own extent and generality by giving surety, as it were, in pointing out new particulars, so that we may neither stop at actual discoveries, nor with a careless grasp catch at shadows and abstract forms instead of substances of a determinate nature; and as soon as we act thus, well authorized hopes may with reason be said to beam upon us."

If the above sentiments were discovered anonymous and couched in more forcible language, it is not impossible that they might be attributed to the owner of the well-known initials T. H. H.

There is good evidence that Huxley failed to grasp the teaching of Bacon. For instance, in criticizing Bacon, Huxley observed: "The desire for 'fruits' has not been the great motive of the discoverer" (Life and Letters, vol. i, p. 486). As we have seen above, fruits and effects are not the objects of research, but the sureties and vouchers for the Truth of Philosophy, just as a correct solution of a problem is a surety of the truth of the calculation.

Then again: "Those who refuse to go beyond fact, rarely get as far as fact" (loc. cit.). Now Bacon is ever insistent on teaching that you must go beyond your facts to your 'axiom'; when, if your axiom is sound, it will carry you on to new facts, or, in Bacon's words, will point out 'new particulars.'

The last quotation, which explains how an axiom is formed from Induction, exactly describes the method by which Darwin formed his great axiom of 'Natural Selection.' What Bacon termed an 'axiom,' Darwin termed a 'theory'; but Huxley strangely always called it an 'hypothesis,' which forty years ago meant no more than an 'assumption.' Now Darwin's theory and Bacon's axioms were far removed indeed from assumptions. It is important to note that the axioma of Science "is that which is assumed as the basis of demonstration," while the axioma of Mathematics is "a self-evident proposition." As Bacon talks of axioms "when established," he infers that they are not always so fortunate; whereas a mathematical axiom is assumed to be established beyond contradiction.

That Huxley should have preached against the Baconian Induction and Experimental Philosophy, has no doubt given rise to a flood of unsound guesswork, and necessitated the Baconian warning: "Nor can we suffer the understanding to jump and fly from particulars to remote and most general Axioms . . . we must not . . . add wings, but rather lead and ballast to the Understanding, to prevent its jumping or flying, which has not yet been done; but whenever this takes place we may entertain greater hopes for the Sciences."

But Huxley, in spite of his heretical preaching, was a staunch Baconian, and never himself lacked the lead and ballast; indeed, in 1894 he wrote: "The *a priori* road to scientific, political, and all other doctrine is H.R.H. Satan's invention—it is the intellectual broad and easy path which leadeth to Jehannum. The King's road is the strait path of painful observation and experiment, and few they be that enter thereon" (L. & L., vol. ii, p. 383).

It would thus seem that Huxley's attack upon Bacon was owing to a misconception of the Baconian Philosophy. Until I read Huxley's aforesaid attacks I had taken the Experimental Philosophy second-hand, from the practice of such men as Darwin, De la Beche, and Lyell; but on essaying to read for myself, I found all the popular editions out of print, and had to purchase a fancy volume valued for its typography. Under these circumstances one is tempted to wonder how many of the critics, of the Huxley school, have even read the "Novum Organum." Some years ago I wrote a somewhat combative paper on "Professorial Research," believing the subject to be original! whereas the "Novum Organum" *opens* with the remark—"They who have presumed to dogmatize on Nature . . . . in the professorial style, have inflicted the greatest injury on Philosophy and Learning." Max Müller, writing in the *Nineteenth Century* in June, 1894, observed that in Germany, "For a philosopher who does not belong to the professorial caste to gain a hearing is extremely difficult . . . . the outsider does not exist." Bacon obviously was an amateur in thought as well as in deed, a rank outsider. Strangely enough, Huxley was equally strong; e.g., "As for government by professors only, the fact of their being specialists is against them . . . . unfortunately, there is among them, as in other professions, a fair sprinkling of one-idea'd fanatics, ignorant of the commonest conventions of official relation, and content with nothing if they cannot get everything their own way"! (Life and Letters, vol. ii, p. 312).

Kelvin v. *Huxley.*

In an address to the Victoria Institute in 1897 Lord Kelvin, referring to an observation of Huxley in 1869 regarding the age of the Earth—viz., "Most of us are, I expect, Gallios who care for none of these things, being of opinion that, true or fictitious, they have made no practical difference to the earth during the period of which a record is preserved in stratified deposits,"—suggested that Huxley's indifference was due to his ignorance that there was valid foundation for estimates worth considering as to absolute magnitudes. But Lord Kelvin entirely ignored Huxley's reply in 1876, when he pointed out that should Lord Kelvin tell him his geological authority was quite wrong, his answer would be, "That is not my affair; settle that with the geologist, and when you have come to an agreement among yourselves I will accept your conclusion" (Coll. Essays, vol. iv, p. 135). No man could say more than this.

Kelvin v. *Darwin.*

Lord Kelvin quotes from Jukes' "Students' Manual" as follows: "Mr. Darwin, in his admirably reasoned book on the origin of species . . . estimates the time required for the denudation of the rocks of the Weald of Kent . . . *at three hundred millions of years*" (Trans. Vict. Inst., vol. xxxi, p. 12).

This Lord Kelvin thinks very foolish, but so did Darwin; for in 1866 he writes to Professor Charles Pritchard, F.R.S.: "That is a very foolish episode of mine about the Wealden, and was struck out in the later editions" (Life of Professor Pritchard, p. 94).

Not only was the passage quoted by Lord Kelvin struck out, viz., "In all probability a far longer period than 300,000,000 years has elapsed since the latter part of the Secondary period," but the whole two pages which referred to the Wealden were rejected.

Kelvin v. *Lyell.*

"Led by Hutton & Playfair, Lyell taught the doctrine of eternity and uniformity in geology" (loc. cit., p. 16).

Lord Kelvin here again entirely ignores Huxley's refutation in 1876, twenty-one years before the old charge was furbished up again, viz., "It is clear that the consistent working out of the uniformitarian idea *might* lead to the conception of the eternity of the world. Not that I mean to say that either Hutton or Lyell held this conception—assuredly not; they would have been the first to repudiate it" (Coll. Ess., vol. iv, p. 52).

Then listen to Lyell himself. "It cannot be denied that our failure to detect signs of them [the vertebrata] in older strata, in proportion to the rank of their organization, favours the doctrine of development, or at least of the successive appearance on the earth of beings more and more highly organized . . . . " (Elements, 1865, p. 586). And again, "It may or may not be true . . . . that the whole planet was once in a state of liquefaction by heat" (loc. cit., p. 90).

There is neither eternity nor uniformity in these passages, petrological or palæontological. It seemed to me such a serious thing that such baseless charges against our most illustrious geologists should not only be brought before a scientific institution, but be sold at a cheap rate to the public, that I sent in my resignation as an associate of the Victoria Institute.

For my own instruction I sought to discuss Lord Kelvin's address with a distinguished geologist and teacher, but he refused either to read the address, to permit me to read extracts, or to discuss it in any way, on the ground that Lord Kelvin was not a geologist, and that it would be an absolute waste of time to discuss his opinions on geology. I then applied to another distinguished man whom Lord Kelvin had criticized, but he had not even taken the trouble to ascertain what had been said of him. In fact, I was not only driven from the geological judgment-seat, but bantered for taking the matter so seriously.

Under these circumstances I attended the Meeting of the British Association at Bradford. To my unbounded consternation I heard my friend Professor Sollas, President of Section C, in the opening passages of his address repeat Lord Kelvin's charge against Lyell, with the addition of a serious reflection on the latter's honesty. After excusing Hutton's ignorance the distinguished President went on to say: "With Lyell, however, the case was different: in pressing his uniformitarian creed on geology he omitted to take into account the great advances made by its sister sciences, although he had knowledge of them, and thus sinned against the light. In the last edition of the famous 'Principles' we read: 'It is a favourite dogma of some physicists that not only the earth but the sun itself is continually losing a portion of its heat, and that as there is no known source by which it can be restored we can foresee the time when all life will cease to exist on this planet, and on the other hand we can look back to a period when the heat was so intense as to be incompatible with the existence of any organic beings such as are known to us in the living or fossil world . . . . a geologist in search of some renovating power by which the amount of heat may be made to continue unimpaired for millions of years, past and future, in the solid parts of the earth . . . . has been compared by an eminent physicist to one who dreams he can discover a clock with a source of perpetual motion and invent a self-winding apparatus. But why should we despair of detecting proofs of such regenerating and self-sustaining power in the works of a Divine Artificer?' Here we catch the true spirit of uniformity; it admittedly regards the universe as a self-winding clock, and barely conceals a conviction that the clock was warranted to keep true Greenwich time" (Sollas, Rep. Brit. Assoc. Bradford, p. 712).

On this passage the charge of sinning against the light is founded. Now it is a matter of no sort of importance whether Lyell was right or wrong, but it is a matter of grave importance to his reputation whether he either weakly deceived himself or wickedly deceived other people.

Sinning against the light was certainly not the character of Sir Charles Lyell, as is well shown by his prompt renunciation of his old principles in favour of Darwinism and the antiquity of Man. Pengelly writes in September, 1862: "In his new book he [Lyell] says he is 'going the whole hog' both in the antiquity of man, and Darwinism, and if any man deserved excommunication he thinks he certainly will" (Life of W. Pengelly, p. 135).

It is always lawful for a man to defend his position until it is proved untenable; and the question is, whether the doctrine of the stability of the solar system and the maintenance of the sun's heat was so thoroughly disproved as to make its continued acceptance scarcely honest.

It is worth noticing that in a very popular book, "The Orbs of Heaven," 1859, by O. M. Mitchell, Director of the Cincinnati Observatory, the following passage occurs: "I see the mighty orbits of the planets slowly rocking to and fro, their figures expanding and contracting, their axes revolving in their vast periods; but stability is there. Every change shall wear away, and after sweeping through the grand cycle of cycles, the whole system shall return to its primitive condition of perfection and beauty" (loc. cit., p. 125).

Lyell died in 1875. In 1882, seven years later, C. W. Siemens, President of the British Association, an electrical expert, propounded the very selfsame electrical self-winding clock theory; for which Lyell has been so severely blamed, not for propounding, but for merely suggesting.

Siemens writes as follows: "In March last I ventured to bring before the Royal Society a speculation regarding the conservation of solar energy," which he proceeds to briefly state, and subsequently proceeds: "If chemical action and reaction can further be admitted, we may be able to trace certain conditions of thermal dependence and maintenance, in which we may recognize principles of high perfection, applicable also to comparatively humble purposes of human life" (Siemens, Rep. B.A. Southampton, p. 33). These theories may or may not be sound, but they were boldly announced from the Chair of the British Association as well as defended before the Royal Society.

And yet again, twenty years later, in 1902, from the most fashionable scientific rostrum in London, that of the Royal Institution, we hear Mr. Wells saying: "Some day this earth of ours, tideless and slow moving, will be dead and frozen, and all that has lived upon it will be frozen out and done with. There surely man must end. That of all such nightmares is the most insistently convincing. And yet one doesn't believe it. At least I do not. And I do not believe in these things because I have come to believe in certain other things—in the coherency and purpose in the world and in the greatness of human destiny. Worlds may freeze and suns may perish, but there stirs something within us now that can never die again" ("The Discovery of the Future," T. G. Wells, *Nature*, 1902, p. 531).

If the Royal Institution listens respectfully in the twentieth century to the unsupported belief that man will survive his frozen globe, and the British Association listened respectfully to Siemens' speculations on such thermal maintenance as would avoid that cold contingency, must Lyell be deemed as sinning against the light if he did not despair of the detention of proofs of a self-sustaining power, the position taken by Lyell being far less confident than that of either Siemens or Wells?

It may be worth while to notice an admirable summary by Phillips of the state of geological theory in 1839: "That the doctrine of progressive cooling of our globe is to be now received as an established theory, those who desire the real progress of geology will prevent themselves from affirming; and perhaps few who have attended to the inferences contained in these volumes will hesitate to believe that it will one day become so. . . . . The figure of the earth, its density, the actual temperature of its surface and interior parts, etc., are all capable of explanation by this one consideration" (Phillips' Treatise on Geology, vol. ii, p. 277).

The earliest teaching I received in geology, some time in the fifties, was, that the figure of the earth, the oblate spheroid, proved its original liquidity; and that catastrophe was "the forlorn hope of an almost extinct body of philosophers." Lyell's Uniformitarian theory was the protest against a series of creations and catastrophes. Like a good cobbler he stuck to his last and left cosmogony to the astronomers and physicists, who alone were competent to deal with it, or at least were supposed so to be. But I must say I have my doubts. Bacon's test for a sound theory is that it shall be able to confirm its own extent and generality by giving surety in pointing out new particulars. If the rule be sound it will prove itself in the example. Now Lord Kelvin's 'Age of the Earth' breaks down completely in his own hands when put to this test. He has worked us an example of his own choosing, wherein, so to speak, every figure is wrong.

Based on his hypothesis of the mode of consolidation of the Earth is Lord Kelvin's conjecture of the 'Probable Origin of Granite,' e.g.: In the primeval lava there arises "a snow shower of solidified lava or of crystallized flakes, or prisms, or granules of felspar, mica, hornblende, quartz, and other ingredients. . . . This process goes on until, by the heaping of granules and crystals on the bottom, our lava ocean becomes silted up to the surface . . . at the stage now reached [we have] a red hot or white hot surface of solid granules or crystals with interstices filled with the mother liquor still liquid, but ready to freeze at the slightest cooling. . . . It was probably this interstitial mother liquor that was destined to form the basaltic rock of future geological time" ("The Age of the Earth," Trans. Vict. Inst., vol. xxxi, pp. 24, 25).

It will be observed that Lord Kelvin's granite is not necessarily even a plutonic rock. Its original crystals of mica, felspar, quartz, hornblende, and other minerals are brought together by gravitation, and have invariably a basaltic matrix. *Ex hypothesi,* it can never be otherwise. Now the questions arise whether a granite of this description has ever been seen by any petrologist, and does it accord with the microscopic character of any known granite? But, granting for the sake of argument the possibility of the formation of such a primeval granite; to what entirely different origin are we to attribute the numerous non-primeval granites in which gravitation, drifting, and surface consolidation are out of the question, and yet granites of different ages are practically indistinguishable the one from the other? Lord Kelvin's theory not only assumes that all the granitic minerals crystallized out of the basaltic magma simultaneously, but that all sank at the same rate, and were therefore all heavier, and equally so, than the residual liquor; whereas, assuming that the granitic minerals, mica, felspar, and quartz, could crystallize out of a magma largely composed of augite and iron, they would tend to rise rather than sink, and these granitic minerals would have consolidated at the surface instead of the bottom. But, as it is an established fact that the granitic quartzes and felspars consolidated under great pressure, in the presence of water in some form, it is clear that granite was formed in some other way than by a shower of crystalline granules.

Geologists have hesitated to propound a 'Theory of Granite,' knowing the difficulties; therefore, Lord Kelvin's theory holds the field. Now, Lord Kelvin's 'Probable Origin of Granite,' and of Basalt, occupies exactly two octavo pages. Within that small space the word 'must' occurs eight times, the word 'probable' or 'probably' six times, 'may have' twice, 'pretty sure' once, 'almost certainly' once. Any one of these words or phrases would suffice to cast suspicion on a new theory; but it is not a case of one, but of eighteen. Such a doubtful 'axiom' must be founded on not a few fallacies, and here are two of them. Lord Kelvin assumes that because consolidated basalt is heavier than molten basalt, and will therefore sink in its own liquor, every mineral crystallized out of the basaltic liquor will also sink. But as is well known, though some minerals are heavier than the liquor, others are lighter. Secondly, Lord Kelvin overlooks the fact that lava, frozen on the surface of a lava-lake, would often entrap bubbles of expanded gases, and be therefore very much lighter than the main mass of the lava, whether solid or liquid. Some of our cosmogonists would do well to refresh their geology by a reference to Lyell on the subject of pumice.

As Lord Kelvin's 'Theory of the Age of the Earth' seems based on the false hypothesis that consolidated basalt and crystallized minerals must necessarily sink in liquid lava, the failure of the hypothesis, or underprop, involves the collapse of the theory. Pengelly's assimilation of the Baconian teaching was much as follows. Every theory is based on many facts, or supposed facts. If a single one of these supposed facts is disproved the whole theory fails. Lord Kelvin assumes that the earth consolidated throughout from within outward, and that the surface was the last to harden. Mineralogy, Petrology, and Geology say—No.

By way of recapitulation I must submit that the charges levelled respectively against Bacon, Huxley, Darwin, and Lyell have all failed, and for the following reasons.

Huxley objected to Bacon only theoretically. In practice he followed him. The Baconian system of working from experience to axiom, from axiom to experience, and back again to axiom, until the latter is established, is the only safe road, and a safe road it is.

Lord Kelvin's attack on Darwin, for an error acknowledged and corrected some thirty-six years previously, is a species of attack which no reputation can withstand.

Lord Kelvin's attack on Lyell is sufficiently repelled by Huxley.

Professor Sollas's charge against Lyell, of what almost amounts to *mala fides*, is disposed of by showing that men of repute have held doctrines even more unorthodox without their good faith being questioned.

I may perhaps be allowed to say that I have myself been compelled to attempt the solution of problems of the most varied character, for none of which I was fitted by previous training; and that under these adverse circumstances I have never known the Baconian method to fail.

Before undertaking the investigation of the age of the Devonshire schists I had never so much as seen a section of schist. After my paper on Ripplemark was in print I heard for the first time of the existence of Airy's standard work on Tides and Waves; and as for petrology, I have never had a couple of hours instruction in my life, to my own infinite loss and regret. Pengelly used to say: "Be careful in scientific enquiries that you get a sufficient number of trustworthy facts, that you interpret them with the aid of a rigorous logic, that on suitable occasions you have courage enough to avow your convictions; and don't be impatient if your friends don't receive all your conclusions, or even if they call you hard names." This is safe advice, and it may be added that if by any possibility two entirely distinct lines of enquiry can be induced to point to the same fact, that fact is probably trustworthy, whereas if three agree it most certainly is so. For instance, if after a gale a dredge indicates a wave-rippled bottom, and if the fauna present are specially adapted to resist waves, and if mathematical theory asserts wave-action at the particular depth—experience, zoology, and mathematics agree, and there is no doubt the bottom is rippled. If, in addition, the ripples can be experimentally reproduced by proportionate waves at a proportionate depth, experience, experiment, zoology, and theory all agree. It is rarely enough that a fact can be assured by four harmonious cross-bearings, but two cross-bearings, if accurate, are sufficient, whereas three are conclusive. For instance, when geology, zoology, and chemistry agree independently as to the age of the Cambrian rocks, or as to the salinity of the sea at that epoch, that much desired information will have been obtained.

In the meantime it is an object still more to be desired, that scientific men should discontinue the practice, first introduced by Huxley, of prosecuting research by the mutual application of 'beak and claws,' as otherwise the only possible effect on the world in general will be the one represented by the following astounding observation made to me by a highly educated man of the world: "Scientists are a disagreeable lot, *not worth controverting*"!

So far as my own observation goes, science has never been at so low an ebb in the estimation of the general public as at present, unless they fancy they see 'money in it.' During the last five years science has been struck four staggering blows. Two have been already mentioned, but perhaps nothing can equal in danger the attack made on British science and the old Universities by the President of Section B at Glasgow, this being coupled with a panegyric on the German methods of teaching and research, together with scathing contempt for the two English Colleges which have ever aimed at the highest attainable standard of education, Trinity and Balliol. Really, one would think Cambridge had done fairly well with such men as Kelvin, Stokes, Rayleigh, Airy, Sedgwick, Bonney, Teall, and Balfour, and scores of others who have made their marks, though not always such deep ones. At the present moment the claims of science are being pressed on the unscientific public in a remarkable book entitled "Anticipations," in which the average intelligent Englishman is severely handled.

It is scarcely fair, but I cannot resist quoting Bacon's judgment on Anticipations and Interpretations. Here it is: "We have accustomed ourselves to call the one method the '*Anticipation of the Mind*,' and the other the '*Interpretation of Nature*.'" He refers to the former method as follows: "And as for those who prefer and more readily receive the former . . . . because they are unable from weakness of mind to comprehend and embrace the other (which must necessarily be the case with by far the greater number), let us wish that they may prosper as they desire in their undertaking, and attain what they pursue." Readers will kindly note that this appalling sarcasm is Lord Verulam's, not mine.

REVIEWS.

I.—A Text-book of Geology. By Albert Perry Brigham, A.M., Professor of Geology in Colgate University. 8vo; pp. 477, with 294 illustrations. (London: Hirschfeld Brothers, Ltd., 1902. Price 6*s*. nett.)

THIS is a clearly written introduction to geology, full of information and yet devoid of detail, and as well fitted as any book with which we are acquainted to stir up interest in the science and to provide the general reader with a knowledge of the principles and leading results of geological investigation. The work is divided into three parts dealing with Dynamical, Structural, and Historical Geology. After a brief introduction of but two pages, the author starts on the geological work of winds. In the course of his remarks he points out the useful lessons that may be learned from the disc of earth lifted by a falling tree, from the ridge and hollow thereby formed, from the erosion that may result from the exposure of the soil to wind and water, or from the obstruction that may arise to drainage. The tearing up to a depth of four or five inches and scattering of soil in one district, or the formation elsewhere of rugged cliffs of calcareous sandstone by wind-drifted beach deposits made up of fragments of shell and coral, afterwards solidified through the cementation of the particles, are again vividly pourtrayed. Illustrations are also given of the loess in China with its dug-out human habitations. Referring to the subject of weathering, and to the minor agent of electricity, mention is made of an irregular train of fulgurites leading off from a tree which was struck by lightning in Florida. The erosive and transporting powers of rivers are dealt with, and the alluvial deposits are traced from their sources in cliff and talus to estuarine deposits and bars. Glaciers, lakes, oceans, and volcanoes receive lucid treatment, and all the subjects are illustrated by diagrams and excellent pictorial views. The illustrations, indeed, are drawn from all parts of the world.

Structural Geology is dealt with briefly, the definitions being in one or two instances too concise, as when we are told that "Hydraulic limestone is so called because when ground it will 'set' under water." From a consideration of the minute structure we are led on to contemplate the "gross structure" of rocks—stratification, folds, and faults, veins, bedded ore, placer deposits, and other phenomena. In the chapter on Physiographic Structures various types of mountains are explained, as well as valleys, lake basins, the development of a land surface in youth, maturity, and old age, and the evolution of drainage.

In the section on Historical Geology the principal formations are briefly described, with especial reference to America, while the fossils are treated, not with respect to the latest nomenclature, but in a broad, general way: thus, a "Carboniferous Crinoid" or "Jurassic Crustacean" is illustrated, while other organisms are generically or specifically designated. Some of the figured fossils are well-known British forms, but the references to physical conditions and economic deposits are essentially American. General questions of correlation are treated in a philosophic spirit, and if we miss any special reference to palæontological zones, and to some other topics, we can without hesitation heartily commend this book to the favourable attention of our readers. H. B. W.

II.—A Bibliography of Stonehenge and Avebury. By W. Jerome Harrison, F.G.S. (Wilts Archæol. and Nat. Hist. Mag., vol. xxxii, December, 1901.)

THIS is a quarto work of 169 pages containing the titles of 947 books, papers, etc., by 732 authors, including 143 who have hidden their identity and appear as "Anon." The authors date from Herodotus, B.C. 450, to Sir Norman Lockyer and Dr. F. C.

Penrose, 1901, whose recent observations indicate that the date of the erection of Stonehenge may be about 1680 B.C. Short abstracts or summaries of the contents of the different books and papers are given, and the work contains some photographic plates of Avebury and Stonehenge. Every important reference to the subject, scientific and literary, appears to have been noted, as may be judged when we mention that George Borrow's "Lavengro," Hardy's "Tess of the D'Urbervilles," and other works of similar character are included in the Bibliography. Geologists will be interested in the works dealing with the character and origin of the materials used in the "Great Stone Monuments of Wiltshire." The subject is a many-sided one, and all interested will feel gratitude to Mr. Harrison for his laborious and, it is needless to add, most carefully executed work. H. B. W.

III.—THE SEA-COAST. By W. H. WHEELER, M.Inst.C.E. 8vo; pp. 361, with 39 illustrations. (London: Longmans, Green, & Co., 1902. Price 10*s.* 6*d.* nett.)

IN this work the author gives the results of his long experience on the coasts of England, Belgium, and Holland, with especial reference to the protection of the land from the ravages of the sea. As an engineer charged with the design of important works for coast-protection, he has given particular attention to the laws which govern the action of waves breaking on the shore, and the effect produced by them on the beach, and on sea-walls and groynes; he has likewise devoted much study to the conditions under which material is drifted along the coast.

In many of the subjects thus dealt with the geologist is more or less interested, especially in the waste on many parts of the coast where "The fight between sea and land is continuous and unceasing." In some localities the cost of preservation of the cliffs may be greater than the value of the land; but as man is sometimes an agent of destruction it is satisfactory to know that when the removal of beach material is shown to be injurious to the coast, the Board of Trade issues an order prohibiting further material being taken away.

From a geological point of view some of the statements of the author require revision, as they lack clearness. Thus, referring to the flint shingle on the South Coast, he remarks that "Many are quite angular, and are still coated with the white colour of the chalk from which they are derived," having, we presume, the white siliceous crust characteristic of chalk flints.

Again, there is a vagueness about the sentence "It seems improbable that the extensive banks of shingle at Aldborough and Weybourne, each several miles in length, can have accumulated from any waste of adjacent cliffs now going on. The present source of supply is derived almost entirely from the waste of the cliffs, and the falling on to the beach of gravel originally deposited on their surface at the breaking up of the glacial period." There is much pebbly gravel in the cliffs at Weybourne, and still more in those of Southwold and Dunwich, from which supplies have been derived for the shingle beach at Aldborough and Orford. Again, in the description and explanation of the Chesil Bank we find that the geological problems are by no means clearly brought before the reader. Thus we are told that "The greater proportion of the flints of which the bank is composed denote an inland rather than a sea-cliff origin, and seem to point to the time of the breaking up of the last great Ice Age, when the valleys and rivers [*sic*] were scooped out by the ice, and the floods due to its melting, and when vast quantities of rock débris and gravel were carried to the coast."

Those interested in the geological explanations of the beach will do well to turn to the original works on the subject, and it would have been better had the author referred to Mr. Strahan's Geology of the Isle of Purbeck and Weymouth (Mem. Geol. Survey, 1898), rather than to his remarks in a discussion on a paper by Dr. Vaughan Cornish. Mr. A. R. Hunt has carried on many important researches on wave action and marine deposits, and a fuller reference to his labours might have been made. He is mentioned in the text, but not in the index. The paper by Mr. Bristow and Mr. Whitaker on the Chesil Bank is noted under the names of H. W. Burton and W. Whitaker.

Fuller and more precise references to original sources of information on our coasts and coast erosion would have added much to the value of this work. As a record of the author's personal observations on the methods of protecting our sea-border, and as a record of the varying characters of our beach deposits, the work will doubtless prove of considerable value and interest both to engineers and geological students.

IV.—Geology of the Argentino-Chilian Cordilleras. By Dr. Carl Burckhardt. Part II. Profils géologiques transversaux de la Cordillère Argentino-Chilienne. Folio. (La Plata, 1900.)

The present work (issued by the Museum of La Plata, under the direction of Dr. F. P. Moreno) embodies the stratigraphic and tectonic results of an expedition made in 1897 by Dr. Burckhardt and Dr. Leo Wehrli, the latter contributing a sketch of the physical geography of the region, which exhibits many interesting glacial and volcanic features.[1]

The rocks dealt with range from the Middle Lias to the Danian, and without any distinct evidence of intermediate erosion. The Jurassic rocks have long been known to form an important part of the region, and Dr. Burckhardt finds in them, especially in the Opalinian, Tithonic, and Berriasian, as well as in Lower Neocomian divisions, clear evidence of an Alpine facies in the fauna. Many forms in the Lower Oolites belong to the littoral zone, and the facts in general do not favour Neumayr's views on climatic distribution.

No evidence of Bathonian has been obtained, but there are strata which may represent this age, although they have not at present

[1] A preliminary report by the authors was published in 1897.

yielded fossils; and the same to a certain extent is the case with Oxfordian (as limited by the author) and Rauracian, though we should in this country from the presence of *Cardioceras Lamberti* recognize portions of our Oxfordian. The strata which occur below the Kimeridgian are largely formed of gypsum, red marls, grits, and conglomerates, and they indicate at any rate somewhat altered conditions.

The identification, or approximate identification, of many South American fossils with European species is comforting, for it enables comparisons to be made much better than if distinct 'specific' names had been given; and as the sequence of the forms is the same in the two areas we cannot doubt that approximate correlation is justified. There appears to be a blending of Kimeridgian and Tithonic forms in the Lower Tithonic.

The following table shows the grouping and the leading fossils noted by Dr. Burckhardt:—

NEOCOMIAN and BERRIASIAN	... ...	*Exogyra Couloni*, Defr. *Lytoceras* cf. *subfimbriatum*, d'Orb. *Hoplites* aff. *occitanicus*, Pict.
TITHONIC	Upper ...	*Odontoceras permulticostatum*, Steuer.
	Lower ...	*Oppelia perlævis*, Steuer. *Perisphinctes colubrinus*, Rein.
KIMERIDGIAN	... ...	*Perisphinctes colubrinus*, Rein. *Perisphinctes polyplocus*, Rein.
RAURACIAN OXFORDIAN	... ...	(Not yet distinguished by fossils.)
CALLOVIAN ...	... ...	*Cardioceras* aff. *Lamberti*, Sow. *Peltoceras athleta*, Phil. *Perisphinctes funatus*, Opp.
BATHONIAN	... ...	(Not yet distinguished by fossils.)
BAJOCIAN ...	... ...	(Upper zones not yet distinguished.) *Sonninia* aff. *Sowerbyi*, Mill. *Amusium* (*Pecten*) *personatum*, Goldf. *Harpoceras opalinum*, Rein.
LIAS ...	Upper ...	(Upper beds united with Lower Bajocian.)
	Middle ...	*Amaltheus spinatus*, Brug.

Between the Neocomian and the Senonian there are strata which have furnished no determinable fossils, but as the formations do not exhibit discordance the author thinks the sequence may be complete. In the Senonian *Gryphæa vesicularis*, Lam., and *Plicatula* aff. *multicostata*, Forbes, are noted; and in the Danian, *Turritella Soaresana*, Hartt, and *Cardita Morganiana*, Rathb.—the *Turritella* being near to *T. ventricosa*, Forbes, and *T. multistriata*, Reuss.

A remarkable fact about the region is that the strata are comparatively little disturbed and plicated; and it thus differs greatly from Alpine regions in the absence of dislocated portions of formations and of any central massif of ancient rocks. In some respects the structure is more like that of the Swiss Jura, from which, however, it is distinguished by the presence of diorites and of extensive neo-volcanic rocks. In the Jurassic series, ranging from the Lias to the Tithonic, there are conglomerates, of more or less porphyritic character, volcanic breccias and tuffs, which appear to replace the strata at various horizons. These rocks will be described in detail in the petrographic portion of the work.

The present volume is illustrated by thirty-two plates of fossils, geological sections, and views, including many effective pictures of glacial and volcanic phenomena as well as of the stratigraphical features in the sedimentary rocks. H. B. W.

V.—The Student's Handbook of Stratigraphical Geology. By A. J. Jukes-Browne, B.A., F.G.S., etc. Large crown 8vo; pp. xii, 589, with 1,000 Illustrations. (London: E. Stanford, 1902. Price 12*s*. nett.)

THAT there must be a fairly constant demand for textbooks on geology is evident from the almost perennial succession of them, mostly by more or less well-known geologists. There is an average sameness about them all: allowing for personal idiosyncrasies, their stratigraphy is 'correct,' while their palæontology, especially as regards nomenclature, is hopelessly out of date, and their illustrations only too frequently as venerable as their subject. Judged on these lines, this, the latest comer of the long series, is a successful production.

The present work, the author tells us in his preface, is a rewritten edition of his "Student's Handbook of Historical Geology," which was issued in 1886 as one of the celebrated "Bohn's Series." The change of title in the present edition more accurately conveys the scope of the work, which does not deal, as the old designation might have led one to infer, with the history of the science itself.

The general plan of the original book has been retained, but the chapters dealing with the Palæozoic rocks have been expanded, and the sections on Palæogeography abridged, since this latter subject has been more fully dealt with in the author's "Building of the British Islands."

Some previous knowledge of geology is indispensable to the student of this volume, and for this he is referred to "any elementary manual of geology" or "the author's *Handbook of Physical Geology*."

The nomenclature and classification of strata adopted by Mr. Jukes-Browne do not materially differ from those employed in other modern textbooks, he having wisely abandoned sundry variations which he proposed in 1885 (Geol. Mag., 1885, p. 297) and incorporated in the former edition of this book. He does, however, introduce the term 'Selbornian,' coined by him in 1900 (Geol. Surv. Memoir, "The Cretaceous Rocks of Britain," vol. i), to include the Upper Greensand and Gault; and for this term there is some justification.

A glance at a modern table of strata brings to mind, with amusement, Ramsay's "Lament for the Good Old Days of William Smith," when

> "Our ancient English was the law
> In geologic volumes."

We have advanced far indeed in the importation of foreign terms since then.

After the introductory portion comes the main body of the work, in which each system is made the subject of a chapter.

As usual in treatises of this class, but scant courtesy is paid to the post-Pliocene deposits, especially the non-Glacial ones. They generally come last, and, like the final letters in an encyclopædia, or the unfortunate Invertebrata in many a so-called Natural History Book, there is no room left for adequately dealing with them. Dare we suggest that the greater difficulty in correctly unravelling their history as compared with their more showy precursors in geologic time has also something to do with the case? Anyhow, the refusal to grant them a 'system' name to themselves is, we think, for many reasons to be regretted.

The order adopted in treating of each system is to give, first, the Nomenclature and Classification, then come the Life of the Period, the Stratigraphy, the Physical Geography, and finally a list of References. Where they lend themselves to it, these sections are appropriately, though we feel bound to say not always satisfactorily, illustrated; while a full index concludes a well got up volume so far as regards paper and print. The illustrations are of very unequal merit. The new maps and sections are most admirable, and so too are some of the figures of fossils. Far too many of these latter, however, are from old and worn-out blocks, like the figure of *Homalonotus* on p. 141, which first did duty so many a long year ago that we scarce like to compute its age; while others, like the cut at the top of the same page, looking like some post-Bank-holiday fragment of feminine adornment, scarcely depict the objects they ostensibly represent. We are thankful to record, however, that the pig-tailed Mammoth with his wooden shoes is conspicuous by his absence.

On the whole Mr. Jukes-Browne is to be congratulated on the attempt he has made to grapple with a difficult subject, and we imply no disrespect to him if we say that it is only too manifest a work of this description can in the future only be successfully brought out if produced under the auspices of a combination of specialists.

A geologist who has worked all his life at stratigraphy has had no adequate opportunity of making himself properly acquainted, for the purposes even of a work of this sort, with the advance of knowledge in the sister sciences of zoology and palæozoology, botany and palæobotany.

Mr. Jukes-Browne will do well, therefore, when preparing future editions, to take counsel with experts in these several sciences. Guided by them, he will see the advisability of making many modifications, such as the breaking up of the list of mammals at present banded together as "New-comers in the older Thames Gravels," and certainly the removal therefrom of the Roman introduction, *Cervus dama*. He will learn that more than one worked flake has been found in the lower brickearth of the Thames Valley below London; and so on, and so on. He will further be assisted in bringing his nomenclature of the fossil forms of life somewhere within the range of modernity.

Even as it is our author might here, of himself, have improved upon what he has done. A little reflection would have convinced him that the emended form '*Vivipara*' was more appropriate than '*Viviparus*,' seeing that so far as known at present male animals do not produce young, and that anyhow *Viviparus vivipara* could not be right.

There are unfortunately numerous nomenclatural inconsistencies to puzzle the student, that should have been eliminated. The worst of these is the treatment meted out to the quondam genus *Ammonites*. Mr. Jukes-Browne has evidently struggled hard to cope with the correct modern divisions, but he has been worsted in the conflict. He starts bravely enough in the middle of p. 334, where the modern (more or less) generic names are employed; but from the bottom of that page, and for some way further on, these same names are treated as subgeneric and placed in parentheses after '*Am.*' Between p. 340 and p. 350, and beneath all the cuts of the Jurassic forms, however, '*Ammonites*' alone appears; thenceforward for some pages the subgeneric method is again followed. Finally, the strain becomes too great, all three styles are employed indiscriminately, with the result that the same species occurs under different forms of names at short intervals, so that, for example, we read of '*Am.* (*Douvilleiceras*) *mammillatus*' on p. 427, of '*Douvilleiceras mammillatus*' on p. 429, and of '*Am. mammillatus*' on p. 430. Poor student!

B. B. W.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—March 26th, 1902.—Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. "On a remarkable Inlier among the Jurassic Rocks of Sutherland, and its Bearing on the Origin of the Breccia-Beds." By the Rev. John Frederick Blake, M.A., F.G.S.

On the coast of Sutherland due south of Port Gower is seen on the scars at low-water a long rocky crest of Old Red Sandstone, with its flaggy beds dipping at a high angle. It is of considerable height, and is surrounded by nearly horizontal Jurassic beds containing large blocks of rocks similar to those of the crest, irregularly placed. The size, outline, and relation to the surrounding rocks show that this cannot be a transported block, but must have been part of, or directly derived from, a neighbouring coast—like the modern sea-stacks of the present coast at Duncansby.

The relations of the Jurassic rocks to the Old Red Sandstone are seen in the Gartymore Burn. The fragments of the latter contained in beds of the former become more numerous as the junction is approached, and ultimately form the whole mass—as would happen in the case of a cliff-talus. It is concluded that the breccia-beds may in part have originated on the spot.

The distribution of the breccia-beds in the Jurassic Series is then considered in detail. Three horizons can be traced in this series, namely, the zones of *Cardioceras alternans*, *Hoplites eudoxus*, and *Perisphinctes Pallasi*. No breccia-beds are found in the first of these, but there are sporadic ones in the second, within which the inlier occurs, and they become very numerous in the third. The ordinary autochthonous fossils, including plant-remains, occur in the intervening shales, but the breccia-beds themselves contain only large heterochthonous fossils, including Rhynchonellas and corals, and where these occur intermediate beds are found, composed of crushed organisms. North of Helmsdale one breccia-bed has apparently squeezed up the underlying shale into an anticlinal arch, against another boss of Old Red Sandstone.

The phenomena thus described are then compared with those which have been actually seen—or which may be inferred to occur in the case of deposits from an ice-foot—and they are found to correspond in a remarkable degree. And it is therefore concluded that the breccia-beds are the product of an ice-foot of Upper Jurassic age, which invaded the normal deposits of that period.

2. "On a Deep Boring at Lyme Regis." By Alfred John Jukes-Browne, Esq., B.A., F.G.S.

During 1901 a boring was made near Lyme Regis in search of coal, and was carried to the depth of 1300 feet without reaching the base of the Upper Triassic Marls. The following abstract shows the formations passed through:—

			Thickness.			Depth.	
			ft.	in.		ft.	in.
SOIL AND GRAVEL			10	8	...	10	8
BLUE LIAS		probably	62	4	...	73	0
RHÆTIC BEDS.	White Lias	,,	22	1	...	95	1
	Black Shales	,,	38	7	...	133	8
	Grey Marls	,,	39	1	...	172	9
KEUPER MARLS, 1129 ft. 3 in.	Marls, without gypsum		124	7	...	297	4
	Marls, with veins of gypsum		118	10	...	416	2
	Marls, with beds of gypsum		313	10	...	730	0
	Gypsiferous marls, with three beds of sandstone		134	0	...	864	0
	Hard clays and marls, with gypsum.		297	7	...	1161	7
	Hard silty and micaceous clays, with some gypsum		140	5	...	1302	0

A full journal of the boring is given, and the beds are compared with those exposed along the cliffs from Lyme to Sidmouth. The exposures of the Rhætic beds near Lyme are described, and the 'tea-green marls' are included in the Rhætic group, although no fossils have been obtained from them in Devon. Reference is made to the difficulty of measuring the Keuper Marls. The site of the boring is in the valley of the stream which enters the sea at Lyme, at a spot about one mile north-west of that town and about half a mile east of Uplyme, close to the boundary between Devon and Dorset. The Blue Lias in the borehole belongs to the zones of *Ammonites Bucklandi*, *A. angulatus*, and *A. planorbis*. Between the depths of 480 and 864 feet three beds of grey, calcareous sandstone were traversed, each from 12 to 15 inches thick, and separated by beds of red and grey, gypsiferous marl. Similar beds occur near Taunton and North Curry, in Somerset. Some of the lowest beds may be called 'siltstones'; they were originally silty muds. The author concludes that the boring did not reach the beds which near Sidmouth form a passage from the Keuper Marls to the Keuper Sandstones, and that the Keuper Marls proved by the boring are at least 1130 feet, and may amount to 1200 feet in thickness.

II.—April 16th, 1902.—Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Carlisle Earthquakes of July 9th and 11th, 1901." By Charles Davison, Sc.D., F.G.S.

The shocks were at least four in number, and there are single records of four other shocks. The isoseismal 5 of the first and principal shock is very nearly a circle 29 miles in diameter, with its centre 7 miles south-south-west of Carlisle, and is excentric with regard to the isoseismal 4. The continuity of the shock over a band extending from Carlisle to Coniston implies a corresponding continuity in the focus. The investigation of the earthquakes has led to the recognition of a deep-seated fault, the average direction of which is N. 5° E. and S. 5° W., and the hade throughout is to the east. In the surface-rocks there is no sign whatever of such a structure. The movements along the fault were somewhat peculiar. In the first shock the focus was of considerable length, and consisted of two principal portions, the centres of which were about 23 miles apart, connected by a region wherein the slipping was continuous throughout, and much less in amount. The northern part of the focus was smaller than the other, but was marked by a much stronger impulse. The third slip was complementary to the first, for it appears to have occupied the whole of the region between the two principal portions of the first focus, and to have been greatest near the centre of that region and to have gradually diminished towards both ends.

2. "The Inverness Earthquake of September 18th, 1901, and its Accessory Shocks." By Charles Davison, Sc.D., F.G.S.

Since the Comrie earthquake of 1839, which was followed by 330 tremors and earth-sounds within little more than two years, no British earthquake has been attended by so many accessory shocks as this one. The unusual intensity of the earthquake, its apparent connection with the great northern boundary fault of the Highlands, and the possibility of tracing oscillations in successive centres of disturbance along the fault surface, combined in rendering a detailed investigation desirable. With a few exceptions, the earthquakes originated beneath the district lying between Inverness and the north-eastern end of Loch Ness. The mean direction of the fault, which follows the line of the Great Glen, is N. 35° E. and S. 35° W., and its hade is to the south-east. The isoseismal 8 contains 67 square miles, and its centre is about $1\frac{1}{2}$ miles east-north-east of Dochgarroch and $\frac{3}{4}$ mile south-east of the fault-line. The correspondence between the position of the great boundary fault and of the fault inferred from the seismic evidence is so close, that there can be little doubt that the earthquake was due to a slip along this fault.

The nature of the shock, the sound-phenomena, time-relations, and after-shocks are described in detail, and some account is added of the earthquakes of 1890 and of sympathetic earthquakes in the valley of the Findhorn. There were two distinct slips in rapid succession, with continuous slight motion between them, the second being greater in amount and extending over an area which probably overlapped, even if it did not entirely include, that within which the first took place. The great slip reached nearly from Loch Ness to Inverness, and was greatest at a point about half-way between. The three chief after-slips resulted in an extension of this area in both directions along the fault-surface, the extension to the north-east being small, while that to the south-west amounted to 6 miles or more. In addition to this migration of the focus, there was also a continuous decrease in the depth of the focus. The earthquakes provide no evidence with regard to the direction of displacement along the boundary fault. There can be little doubt, however, that Loch Ness is still growing; but it can hardly be determined whether the lake is now contracting in area, or whether it is gradually pushing its way outward to the sea.

3. "The Wood's Point Dyke, Victoria (Australia)." By Frederic Philip Mennell, Esq., F.G.S.

This dyke is intrusive into a belt of Silurian (Upper Silurian) strata which strike in a direction somewhat west of north, and extend beyond Walhalla on the south. Wood's Point is about 75 miles east of Melbourne. It may be taken as typical of the intrusions associated with the Silurian rocks of the Victorian goldfields. Brown, original hornblende is the dominant constituent, but it is rarely idiomorphic; augite, three varieties of felspar, micropegmatite, and ilmenite are also present in a microcrystalline or cryptocrystalline groundmass. The rock is called a hornblende-porphyrite. In certain varieties cordierite occurs, and is accounted for by derivation from the adjacent shales. The reefs in the Silurian and Ordovician rocks usually occur at or near the contact with intrusive rocks. At Wood's Point the reefs are nearly horizontal, traversing dykes and shales, the junction usually marking the occurrence of rich ore. The author notes the "almost invariable association of gold in this class of deposit with rocks containing original hornblende."

CORRESPONDENCE.

THE CRYSTALLINE LIMESTONES OF CEYLON.

Sir,—As one of the unfortunates who are unable to attend the meetings of the Geological Society, I crave permission to make a comment on the interesting paper on "The Crystalline Limestones of Ceylon" read on the 12th March by Mr. Ananda K. Coomára-Swámy. The author and all his critics profess themselves more or less puzzled by the phenomena described. No mention is made of a theory which would, I think, remove the chief difficulties mentioned. I suggest that the true explanation is deformation *plus* chemical segregation. The author rejects deformation (1) because the minerals are not deformed. But this is not to be expected in a rock which has undergone advanced metamorphism. The author assumes that the minerals are original, whereas the rock may have been transformed, as in the Malvern Hills, where some of the gneisses are entirely composed of secondary minerals, and show no trace of the deformation which was evident enough in an earlier stage of the metamorphism. The author objects (2) that the minerals whose distribution are the chief cause of the foliation are not "such as to have been produced" by earth-movements. I cannot see why. During the reconstruction of the rock the segregation of the carbonates of lime and magnesia may well have been accompanied by the crystallizing out of the accessory lime and magnesia silicates. The hypothesis I have suggested accounts for three facts which appear to have caused considerable perplexity, viz.: (1) the isolated masses of granulite, (2) the lenticular form of some of the granulite masses (one would like to know if any of the limestones are lenticular), and (3) the subordination of the limestone to the silicate rocks. The theory of the origin of limestones by segregation from plutonic rocks during deformation, as in the case of the crystalline limestones of Bodwrog and Porth Trecastell in Anglesey (Report Brit. Assoc., 1887, p. 706), has not yet, I think, received the consideration it deserves. C. Callaway.

Cheltenham.

ON THE OCCURRENCE OF *SCALARIA COMMUNIS* IN THE RAISED BEACH ON THE THATCHER ROCK, AND OF *PECTEN MAXIMUS* AND *VENERUPIS*, sp., AT HOPE'S NOSE.

Sir,—In the year 1888 I published in the Transactions of the Devon Assoc. a list of shells found in the Raised Beach on the Thatcher Rock in Torbay.

In due course I sent a reprint to my friend and colleague the late Mr. D. Pidgeon, F.G.S., which Mr. Pidgeon took the practical and ingenious course of returning to me crowded with copious comments and criticisms. As Mr. Pidgeon took the extreme line of denying the genuineness of the Raised Beaches, and I did not feel disposed to seriously entertain this objection, I laid my friend's notes on one side and forgot all about them.

Last Easter, in looking for a copy of my paper for a friend joining the excursion of the Geologists Association to the Gower Caves, I found Mr. Pidgeon's returned copy. In it I discovered a rather important fact, viz., an additional shell to what I believe is already the record list for any one Raised Beach, viz., *Scalaria communis*. Mr. Pidgeon also added his initials to *Aporrhais pes-pelecani*, a species before certified by Mr. J. T. Marshall. *Scalaria communis* makes the grand total of species from the Thatcher beach 44, a total which made Mr. Pidgeon remonstrate, "there are a great many too many shells, both species and individuals, for a beach." A curious puzzle, but a beach it nevertheless is.

The late Sir Joseph Prestwich embodied my Thatcher collection in his table of the "Mollusca of the Raised Beaches" (Q.J.G.S., vol. xlviii, p. 300).

Anyone interested in the investigation may be pleased to add three species to Sir J. Prestwich's total of 64,[1] viz., *Scalaria communis*, from the Thatcher, on the authority of Mr. D. Pidgeon, and *Pecten maximus* and *Venerupis*, sp., from the Hope's Nose beach, on the authority of the late Mr. Godwin-Austen.[2] Mr. Godwin-Austen described the *Venerupis* as *decussata*, but as that is not a British shell it was probably *V. irus*.

I hope to publish Mr. Pidgeon's criticisms and to discuss them in the transactions of a provincial society. He was one of the acutest of observers, and his detection of the perfect preservation of the sculpture of the Raised Beach shells was one of the most important observations ever recorded on the subject, and one by no means easy to explain. A. R. Hunt.

Torquay, *May* 8, 1902.

SUB-OCEANIC RIVER VALLEYS.

Sir,—To those who have given some attention to the above subject the following statement may prove interesting.

In the recent work, "The Scenery of England," by Lord Avebury, F.R.S., I had the gratification on turning over its pages to find sympathetic reference to my investigations into the phenomena presented by the submerged river valleys of the British Islands and Western Europe, but coupled with a caution "that perhaps I had carried the argument further than the facts entirely warranted."

In thanking Lord Avebury for his kindness in presenting me with a copy of his book, I referred to this caution, which I regarded as quite natural, and added that it would give me much pleasure to afford his Lordship an opportunity of examining the Admiralty Charts themselves, in order that he might judge for himself whether I was justified in my conclusions as to the position and depth below the surface of the ocean to which these "drowned river valleys" descend.

Accordingly a day was kindly arranged for the examination of the Charts, which Lord Avebury examined with the greatest and most intelligent care, and at the end he expressed his gratification at the result.

His Lordship is now, I understand, preparing a new edition of "The Scenery of England," and a few days since I had the pleasure of receiving from him a letter in which he says: "After looking at your maps I am omitting the sentence in p. 106 in which I express a cautious doubt" in regard to your conclusions. This candid acceptance of my views may, perhaps, have some weight with those geologists who have opposed my views, but who have not taken

[1] Q.J.G.S., vol. xlviii, p. 301, Prestwich writes 64 species, but the list shows only 63.
[2] Trans. Geol. Soc., vol. vi, p. 442.

the only course by which they can be properly tested; that is to say, by tracing for themselves the isobathic contours on the Admiralty Charts by means of the soundings.

Before concluding I wish to call attention to a remarkable corroboration of these views which has recently appeared from another quarter. In his elaborate work on the Glacial Geology of the Christiania Region of Norway, in which the variations of level at successive epochs are elaborated, Professor Brögger[1] says: "the occurrence at great depths of the Norwegian Sea of the high-arctic fossil shallow-water Mollusca of the 'Yoldia fauna' is explained by the hypothesis, that the sea-bottom during the time of the greatest ice-sheet of Europe must have been uplifted at least 2,600 métres higher than it is at the present." It is remarkable that this amount of uprise corresponds very closely with that determined by myself; namely, 1,200 fathoms (7,200 feet) as the elevation of Western Europe during the intensest cold of the Glacial period. The maximum elevation was coincident with the stage of maximum cold of that long period; they were, in fact, cause and effect. We require no other explanation for the cause of the intense cold, and the subsequent changes of climate, than the oscillations of level of land.

EDWARD HULL.

THE UPPERMOST CHALK OF THE BALTIC.

SIR,—In his valuable communication "On some Crustacea . . . from the Upper Cretaceous of Faxe" (GEOL. MAG., Nov. 1901, p. 487) Dr. Henry Woodward has copied from Dr. K. O. Segerberg's paper "De Anomura och Brachyura Dekapoderna inom Skandinaviens Yngre Krita" (Geol. Fören. Stockholm Förhandl., xxii) certain statements concerning the geology of the Baltic Uppermost Chalk (Yngre Kritan). Since these might mislead English readers, I ask leave to correct them.

Since 'Faxekalk' is identical with 'Corallkalk,' it is incorrect to say that "The lower layer of the Faxe Chalk is . . . . largely composed of corals, hence called coral-chalk." Even if the term 'Faxekalk' be applied to the whole of the Uppermost Chalk, the expression is misleading, since the bottom bed of the Uppermost Chalk does not consist of the Corallian Limestone (Faxekalk *sens. str.*), but this latter itself rests on a bed of coccolith-limestone (Saltholmskalk).

The hardness of the coccolith-limestone depends on a secondary cementing through calcite-crystals or flinty matter, a process in no way restricted to any definite horizon; looser varieties of this limestone are found just as much in its lower levels as "in the upper layer."

The coccolith-limestone forms the main facies; here and there on the coccolith-ooze there sprang up coral banks or groves of bryozoa; but the shower of coccoliths proceeded unchecked, so that

[1] "Om de Senglaciale og Postglaciale Nivaforandringer i Kristianiafeltet," pp. 682–3.

on and around the coral or bryozoan masses was deposited a coccolith-ooze of the same constitution as that lying under them. The formation of corallian or bryozoan limestone was not connected with any particular period, so that these rocks may occur at any horizon in the coccolith-limestone, the corals in island-like reefs but the bryozoa in extended sheets.

The Uppermost Chalk of the Baltic contains neither *Belemnitella mucronata*, as stated by Prestwich (Geology, 1888, ii, pp. 7 and 302), nor any other belemnite. It was formed in the period between the Upper Maestrichtian and the Eocene, and has no marine equivalents in Western Europe.[1] ANDERS HENNIG.

LUND, *May* 8, 1902.

OBITUARY.

JOSEPH NOLAN.

BORN 1841. DIED APRIL 20, 1902.

THE late Mr. Joseph Nolan, who died at Clonturf, Dublin, on the 20th April, was born in Queen's County, Ireland, in 1841. In early life he attained a sound knowledge of geology from attendance at Jukes's lectures in the Museum of Irish Industry (now Royal College of Science), Dublin.

In 1867 he was nominated by Professor Jukes (then Director of the Irish Geological Survey) for appointment as one of the Assistant Geologists, and in this capacity surveyed with great keenness many important districts in Ireland. Prominent amongst these were the complicated areas of South Mayo and the volcanic region of Carlingford and Slieve Gullion, of which latter the late Sir Andrew Ramsay wrote (in his preface to Mr. Nolan's memoir on Sheet 70 of the one-inch geological map of Ireland): "There is as much interesting matter for discovery and description crowded into a small area as there is to be found in any part of the British Isles." The geological features of the wild mountainous tract which extends through North Tyrone into the Dungiven region in Co. Derry, of the country surrounding Derry City, and portions of Donegal, were ably dealt with by Mr. Nolan; his work in the field being explained in numerous descriptive memoirs which he wrote to accompany the maps.

Mr. Nolan, who was for some thirty years a member of the Royal Irish Academy, took deep interest in the literature, lore, and antiquities of his native country, and his work on the "History and Antiquities of Glendalough" is well-known in antiquarian circles.

Upon the reorganization of the Irish Geological Survey in 1890, Mr. Nolan was appointed "Senior Geologist" to take charge of the office, a post from which he retired only within the past year. His kind and gentle presence will long be greatly missed by his colleagues on the Survey, and by all others who enjoyed the pleasure of his friendship. R. C.

[1] See Hennig, "Studier öfver den Baltiska Yngre Kritans bildningshistoria": Geol. Fören. Stockholm Förhandl., 1899, xxi, pp. 19 and 133.

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ORIGINAL ARTICLES.

I.—Additional Note on *Drepanaspis Gemündenensis*, Schlüter.

By Dr. R. H. Traquair, F.R.S., F.G.S.

In my "Notes on *Drepanaspis Gemündenensis*, Schlüter," published in the Geological Magazine for April, 1900 (pp. 153–159), I described a paired plate of a trapezoidal form occupying a position on each margin of the under surface of the head, a little behind the mouth, and to which I gave the name 'sensory' plate, as it is perforated by an opening which, if not orbital, evidently marks the place of an organ of sense of some sort. With this opening I also identified a depression seen in some specimens in a similar position on the dorsal aspect, and came to the conclusion that its position was *marginal*, being seen in some specimens on the ventral and in others on the dorsal surface of the head. I was also much puzzled to find that in some specimens this pit or depression seemed to have a *floor*, covered with tubercles like those of the rest of the surface, a condition which apparently militated very decisively against the idea of its being an orbit.

Increase of material has enabled me to clear up this point at last, and to rectify my restored figures accordingly.

I found, namely, that when the appearance in question is seen on the ventral aspect (*x*, Fig. 2), it is, in all cases, an actual perforation, but when seen on the dorsal it is a mere depression surrounded by a slightly elevated margin and provided with an imperforate tuberculated floor. Isolated specimens of the sensory plate show also that it was not reflected round the lateral margin of the head (it is not so at least in the fossils), and when I obtained a view of the plate from its *internal* surface, the perforation was found to be surrounded by a thickened ring-like margin. Here, then, is an explanation of the imperforate pit seen on the dorsal surface. For it is now quite clear that this appearance is caused by one of the dorsal plates being *squeezed down upon* the aforesaid thickened ring-like margin of the round opening in the sensory plate, which accordingly *shows through*, although the opening itself is on the ventral surface, as shown in Fig. 2, *x*.

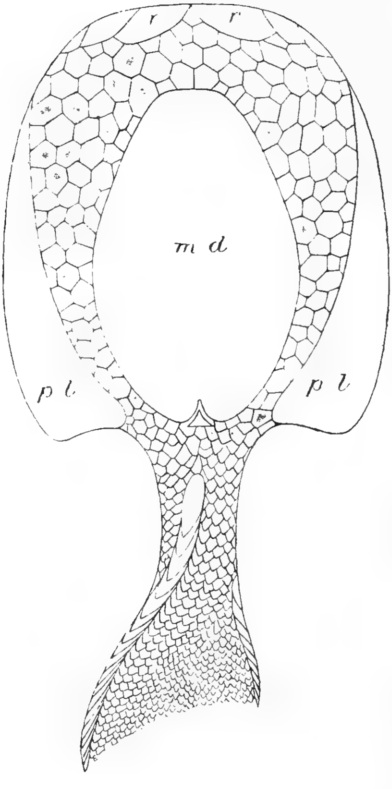


FIG. 1.—*Drepanaspis Gemündenensis*, Schl. Restored outline of the dorsal aspect, the surface ornament omitted, and the tail twisted round so as to show the caudal fin in profile. *m.d.* median dorsal plate; *p.l.* postero-lateral plates; *r.* rostral plates.

Consequently the object *x* is an actual opening which perforates a special plate (sensory) belonging to the ventral aspect of the head, and the appearance of a pit on the dorsal aspect is due to pressure during fossilization, and should be deleted from the restoration, as I have done in Fig. 1.

That this opening, which, though perforating a plate belonging to the ventral surface, lies just within the lateral margin of the head, corresponds to the supposed orbit of *Pteraspis,* does not, I think, admit of any reasonable doubt.

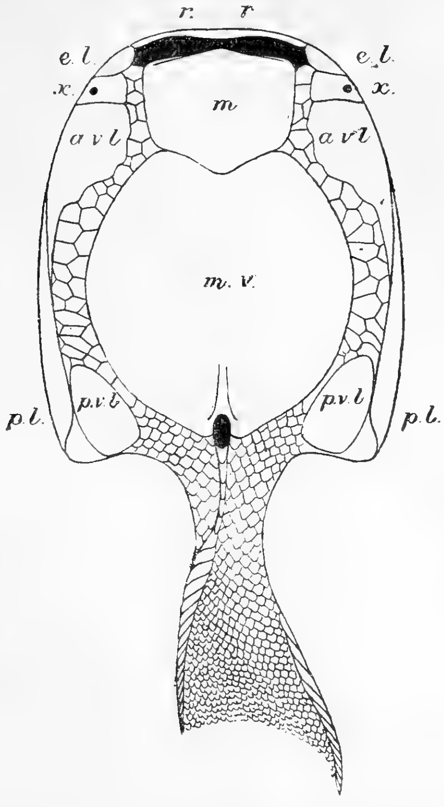


FIG. 2.—Restored outline of the ventral aspect of *Drepanaspis Gemündenensis,* Schl. Surface ornament omitted, and the tail twisted round so as to appear in profile. *r.* rostral or upper labial plates; *e.l.* external labial plates; *x.* sensory openings (orbits ?); *a.v.l.* anterior ventro-lateral plates; *m.v.* median ventral; *p.v.l.* posterior ventro-lateral; *p.l.* postero-lateral or cornual plates. Mouth and supposed cloacal opening indicated in black.

II.—Preliminary Note on some Recently Discovered Extinct Vertebrates from Egypt. (Part III.)

By Chas. W. Andrews, D.Sc., F.G.S., British Museum (Nat. Hist.).

MORE detailed examination of the material collected by Mr. Beadnell and myself in the Fayûm in 1901 has led to the recognition of two additional species of *Mœritherium,* and has made it clear that the Sirenian belongs to a distinct genus, which presents some characters of much interest and is nearly related to *Prototherium* (*Halitherium*) *veronense,* described by Zigno from remains found in beds of Upper Eocene age at Monte Zuello in Northern Italy.

It is desirable to give brief preliminary notes on these species, the full description of them being reserved for the monograph on the whole collection which is being prepared.

Mœritherium gracile, sp.n.

This species is a smaller and rather more lightly built form than *M. Lyonsi.* The skull is more elongated in proportion to its width, the palate is narrower, and the squamosal region of the side of the skull is swollen so as to form a slight rounded protuberance, owing apparently to the great development of the diploe in the squamosal and its consequent thickening. The occipital surface also presents some differences from that of *M. Lyonsi,* particularly in the comparative narrowness of the escutcheon-shaped plate formed by the supra-occipital and in the smaller extent of the periotic that is exposed.

The teeth present the most easily recognized peculiarities. The cheek-teeth are much smaller than in *M. Lyonsi.* They are arranged in perfectly straight lines, the right and left series being almost parallel with one another; the palate is very narrow.

The chief points in which the tooth structure is distinguished from that seen in *M. Lyonsi* are:—

(1) In p.m. 2 and p.m. 3 the shelf-like surface on the postero-internal border is wanting, and in p.m. 3 at least there seems to have been a distinct postero-internal cusp in its place, but none of the specimens are very well preserved.

(2) The cingulum is much more strongly developed than in *M. Lyonsi,* and the enamel is marked by a peculiar sculpture consisting of fine irregular vertical fluting. The form and arrangement of the incisors and canines are as in *M. Lyonsi.*

The dimensions of the upper teeth are:—

	Length.	Width.	
p.m. 2	22 mm.	18 mm.	
p.m. 3	20 ,,	23 ,,	
p.m. 4	20 ,,	21 ,,	
m. 1	23 ,,	23 ,,	
m. 2	24 ,,	25 ,,	(approx.)
m. 3	28 ,,	24 ,,	

Total length of p.m. and m. series	137 mm.
,, ,, p.m. series	62 ,,
,, ,, m. series	75 ,,

In *M. Lyonsi* the length of the p.m. and m. series is approximately 160 mm. and of the p.m. series is 74; and in the width of the teeth the difference between it and *M. gracile* is still greater: thus in *M. Lyonsi* the width of p.m. 3 is 27 mm. and m. 2 27, while in the present species the same teeth measure 20 and 24 respectively.

Mœritherium, sp.

The other species is known only by a nearly complete vertebral column, differing from that of *M. Lyonsi* both in its larger size and in many small structural points. In the absence of any well-preserved remains of the skull and teeth of this form it seems advisable for the present to refrain from giving it a name until further material is available. The occurrence of these three species of *Mœritherium* in a small area seems to point to the conclusion that these animals were a dominant type of the fauna of the region, and possibly it will be found that they form a group divisible into several genera.

EOSIREN LIBYCA, gen. et sp. nov. (Figs. 1–3.)

Two species of Sirenians have already been discovered in the Eocene beds of Egypt, both being from the white Mokattam Limestone of Cairo. Of these one was described by Owen under the name *Eotherium ægyptiacum*,[1] on the evidence of a natural cast of the cranial cavity; the other was described by Filhol from three lower molars, and was named *Manatus Coulombi*.[2] Since both these species, if indeed they are distinct, occur on nearly the same horizon as the specimens from the Fayûm, it will be necessary to consider whether the latter may not be identical with one or both of them.

According to Filhol the lower molars, which he made the types of *Manatus Coulombi*, differ only in small details from those of *Manatus australis*, and he did not think that they could belong to *Eotherium ægyptiacum*, because the brain of that species indicates a much more primitive type of Sirenian than the living genus. In any case, whether he was right in referring his species to *Manatus* or not, the dentition of the Fayûm species is widely different from that of the Manatees, and therefore it must be assumed to be distinct from *M. Coulombi*.

In the case of *Eotherium ægyptiacum*, as already mentioned, the type is the cast of the brain-case, and fortunately it has been possible to make a similar cast from one of our specimens, so that the two forms are directly comparable. Dr. Elliot Smith[3] has examined these casts, and he has come to the conclusion that the two forms are distinct.

It thus appears that our species is distinct from those previously described from Egypt, and its relations must be sought elsewhere. From the Eocene of Italy Zigno has described several Sirenians, the best known being first named *Halitherium veronense*,[4] but afterwards referred by the same writer to a new genus, *Prototherium*,[5] which, however, he never fully defined, merely stating that it included Eocene Sirenians in which the mandible bears a prominent posterior (surangular) process. In many respects, e.g., in the general form

[1] Owen: Quart. Journ. Geol. Soc., vol. xxxi (1875), p. 100. The generic name *Eotherium* had been previously employed by Leidy in 1853 for a genus of Perissodactyla, and therefore, strictly, the name *Eotheroides* suggested by Palmer (*Science*, N.S., vol. x, 1899, p. 494) should be employed for this Sirenian, but in the present paper I prefer to continue to use the name by which it is best known.

[2] Bull. Soc. Philomathique de Paris, ser. VII, vol. ii (1878), pp. 124–5.

[3] Dr. Elliot Smith's descriptions of these and other brain-casts from the Fayûm will be published in the proposed monograph on that district.

[4] Zigno, "Sirenii fossili trovati nel Veneto": Mem. Inst. Veneto d. Sci., vol. xviii (1875), p. 445.

[5] Zigno, "Quelques Observations sur les Sirenians fossiles": Bull. Soc. géol. France, vol. xv (1887), p. 731.

of the skull, particularly of the rostrum, *Prototherium veronense* seems to be closely similar to the Fayûm form, but since it is very doubtful on the one hand whether it possessed canines and posterior incisors, and on the other, whether the process on the mandible which characterizes it, is present in the Egyptian form, it is best to establish a new genus for the reception of the latter.

Fig. 1.

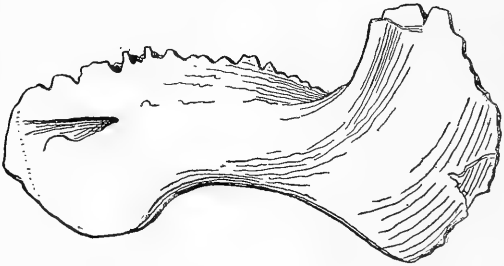
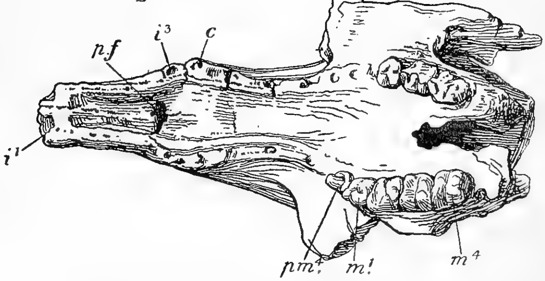


Fig. 3

Fig. 2



Skull and mandible of *Eosiren libyca*. One-third natural size.
Figs. 1 and 2.—Skull. Fig. 3.—Mandible.
p.f. palatine foramen ; i^1, first incisor ; i^2, i^3, second and third incisors ; *c*, canine ; *p.m.*^{4} last premolar ; m^1, m^4, first and fourth molars.

The name *Eosiren* may be adopted for this genus, which will include Eocene Sirenians in the upper jaw of which the anterior incisors (i^1) are modified to form a pair of downwardly directed tusks, and there are also one or two pairs of small laterally placed incisors (i^2, i^3) near the premaxillo-maxillary suture. Canines (c) were present; both these and the posterior incisors were probably shed early in life. The upper cheek-teeth are eight in number, consisting of four single-rooted teeth (premolars) and four double-rooted molars, the crowns of which are bilophodont, each ridge being distinctly composed of two tubercles. (Figs. 1, 2.)

The downwardly deflected symphyseal region of the mandible is greatly thickened and very massive; it bears the alveoli of four pairs of teeth, apparently the incisors and canines. The anterior pair of these alveoli is comparatively shallow, and in all probability the teeth were lost early, this region being covered by a horny sheath. There were probably three single-rooted and five double-rooted cheek-teeth; but this is uncertain owing to the want of well-preserved specimens. There are indications that a replacement of the molars from behind was already established in this early form, at least in the mandible. (Fig. 3.)

The vertebral column is much like that of *Halitherium*, and the scapula is characteristically Sirenian in form, having a backwardly curved, sickle-shaped blade. The rudimentary os innominatum is similar to that of *Halitherium Schinzi*, but the acetabulum is more strongly defined. The species from the Fayûm may be called ***Eosiren libyca***. The dimensions of the type skull are :—

	mm.
Extreme length in straight line	290
Width at occipital condyles	75
Width of foramen magnum	34
Height of foramen magnum	22
Width between supra-orbital processes	87
Width of cranial roof between the temporal fossæ ...	47
Width of snout in front of external nares	45
Length of dental series from canine to last molar... ...	114
Length of molar series	56
Length of external narial opening	64
Width of external narial opening	30

The mandible figured was not associated with the skull, but was found on the same horizon and in the same locality.

It is interesting to note that the alveoli for the posterior incisors and the canines are not borne on the alveolar border of the upper jaw, but seem to have been thrust somewhat outwards on to the facial surface, probably through the development of the horny plate which formed the actual biting surface of the anterior portion of the jaw. It is remarkable that, except in the presence of posterior incisors and canines, this early (Middle Eocene) Sirenian is scarcely at all more generalized than the later *Halitherium*, and it appears that the Sirenia must have branched off from their parent stock at an extremely early period. In some respects, particularly in the structure of the teeth and of the humerus, there is a certain similarity with *Mœritherium*, and it seems not improbable, therefore, that the relationship between the Sirenia and the Proboscidea suggested by Blainville and others may have a real existence.

III.—Geological Age of the Ogasawara Group (Bonin Islands) as indicated by the occurrence of Nummulites.

By S. Yoshiwara, Science College, Imperial University, Tōkyō, Japan.

In the geotectonics of the Japanese Islands, neo-volcanic eruptions in chains parallel to the direction of their elongation play an important part. Dr. Harada[1] has counted three of them on the north, and four on the south of Kwantō, where the mountain-systems of northern and southern Japan are confluent. Besides, there are three chains across Japan. They are (1) the Kirishima chain running from N.W. to S.E., in the southern part of Kyushū; (2) the Chishima chain in Hokkaidō running from N.E. to S.W.; and (3) the Fuji chain forming the boundary of northern and southern Japan (Fig. 1). In a part of the Myokō volcanic group forming the northern extremity of the last important chain, there are the volcanoes of Onigajō, Myokō, Kurohime, and Iijuna, all of which have erupted, according to Mr. Yamazaki, through the Neogene Tertiary (probably Miocene). The southern continuation of this group is that of Yatsugatake, consisting of about nine volcanoes. Further on the south stands Mt. Fuji, formed in the Pliocene or Diluvium, like its southern neighbour Ashitaka-yama, which, according to Mr. Hirabayashi, more early reposed. In the Hakone and Atami volcanoes, also in the Fuji chain, eruption took place, according to him, first in the Pliocene epoch, but chiefly in the Diluvial. The Izu peninsula, a part of this chain, described geologically by Mr. Ishihara, has several volcanoes — Necogoe, Jaishi, Amagi, Daruma, Sukumo (?), and Ajiri (?). On the southern part of the Fuji chain lying in the sea, there are found the small islands collectively called Izu-shichitō. Tracing further southwards, we have Aoga-shima,[2] Bayonnaise Rocks, Smith's Island, Tori-shima (Ponafidin Is.), Lot's Wife Rock, the Ogasawara group (Bonin Islands), the Sulphur Is. group (Volcano Islands), and the islands of the Mariana or Ladrone group, all of which, being of neo-volcanic origin, had been until recently regarded as a continuation of the Fuji chain (Fig. 1).[3] However, in order to study their true geological relations, I spent about one month (July to August, 1901) in visiting all the islands of the Ogasawara group, except the Muko-jima sub-group, and I came to quite a different conclusion.

The Ogasawara group is divisible into three sub-groups. The northern part is the sub-group of Muko-jima (Parry gr.), containing Kater Island together with Nakōdo-jima, Yome-jima, Kitano-shima, Harino-iwa, etc. The middle one is that of Chichi-jima, comprising Chichi-jima (Peel Is.), Ani-jima (Buckland or Hog Is.), Otōto-jima (Stapleton or North Is.), Higashi-jima (Sandy Beach Is.), Nishi-jima (Little Goat Is.), Minami-jima (Long Is.),

[1] Harada: "Die Japanischen Inseln," 1890.
[2] *Shima* (pronounced *Jima* in combination) means island or islands.
[3] Harada: "Die Japanischen Inseln," 1890. Kikuchi, "On Pyroxenite Compounds in certain Volcanic Rocks from Bonin Island": Journ. Coll. Sci. Imp. Univ., vol. iii (1890).

Hitomaru-jima (Charles Little Is.), Hyotan-jima (Pihi Is.), Yagi-jima (Goat Is.), and Kitano-shima (Fig. 2). The southern part is the sub-group of Haha-jima (Barley or Coffin gr.), with Haha-jima (Hillsborough Is.), Ane-jima (Perry Is.), Imōto-jima (Kelly Is.), Mei-jima, Hira-shima, Mukō-jima (Plymouth Is.), Maru-shima, Futago-jima, Matsunbōshi, and others (Fig. 3). All the islets of the Ogasawara group are arranged in a line running 27° 40′ N. to 26° 38′ N. Far to the south-west of Haha-jima there is another group called Sulphur Is. (Volcano Islands), comprising Kita-iwō (San Alessandro Is.), Iwō (Sulphur Is.), and Minami-iwō (San Augustino Is.), (Fig. 1). All the islets of the Ogasawara group show the same geological formation. The chief rock in the Chichi-jima sub-group is agglomerate tuff alternating with andesite lava. On the island of Chichi-jima, a very fine tuff is exposed on the west of Omura and the north of Mikazuki-yama, where we rarely find thin strata of shale. The volcanic rock is almost all augite-andesite. That on the north of Futami harbour (Port Lloyd) in Chichi-jima and on Ani-jima and Otōto-jima is black-coloured with resinous lustre, sometimes changed to a green weathered mass, and is often broken by fissures into large polyhedral fragments. Beautiful crystals of heulandite, apophyllite, analcime, and chabasite are found as druses only in this black andesite. The same rock is also found on the southern coast of Chichi-jima and north of Hatsune-ura on the east coast of the same islet. The andesite exposed on Haha-jima and Kominato in Chichi-jima is blackish-grey to light-grey, with gas pores filled with white silica. Specimens from Ōgiura, Kitafukurozawa, north-east of Tatsumi-ura, and the neighbourhood of Taka-yama in Chichi-jima, belong entirely to vitro-andesite. Mr. Suzuki[1] has described serpentine from Kurose in Otōto-jima. Numerous liparite dykes pass from the south-western corner of Ani-jima to the north-eastern of Chichi-jima. The same rock is not found elsewhere on the Ogasawara and Sulphur Is. groups. In the Haha-jima sub-group we find, besides the predominant agglomerate tuff, several varieties of andesite. Vitro-andesite is frequently met with near Oki-mura and in the neighbourhood of Chibusa-yama in Haha-jima. Andesite having large phenocrysts are principally exposed on the west of a line drawn from Kita-mura to Big Bay in Oki-mura. Andesites are also found in the isolated islets of Imōto-jima and Mei-jima. Generally speaking, the Haha-jima sub-group has the same structure as that of Chichi-jima. *These two sub-groups are typical submarine volcanoes, which sent out numerous streams of lava by subsequent eruptions after frequent periods of repose.* With regard to the sub-group of Muko-jima, which I could not personally visit, I have obtained a series of rock-specimens. The islands in this group, situated in the same direction as the Chichi-jima and Haha-jima sub-groups, judging by the specimens, must show the same geological structure.

[1] Suzuki, "Petrography of the Bonin Islands" (in Japanese): Bull. Geol. Soc. Japan, vol. i, No. 1 (1885).

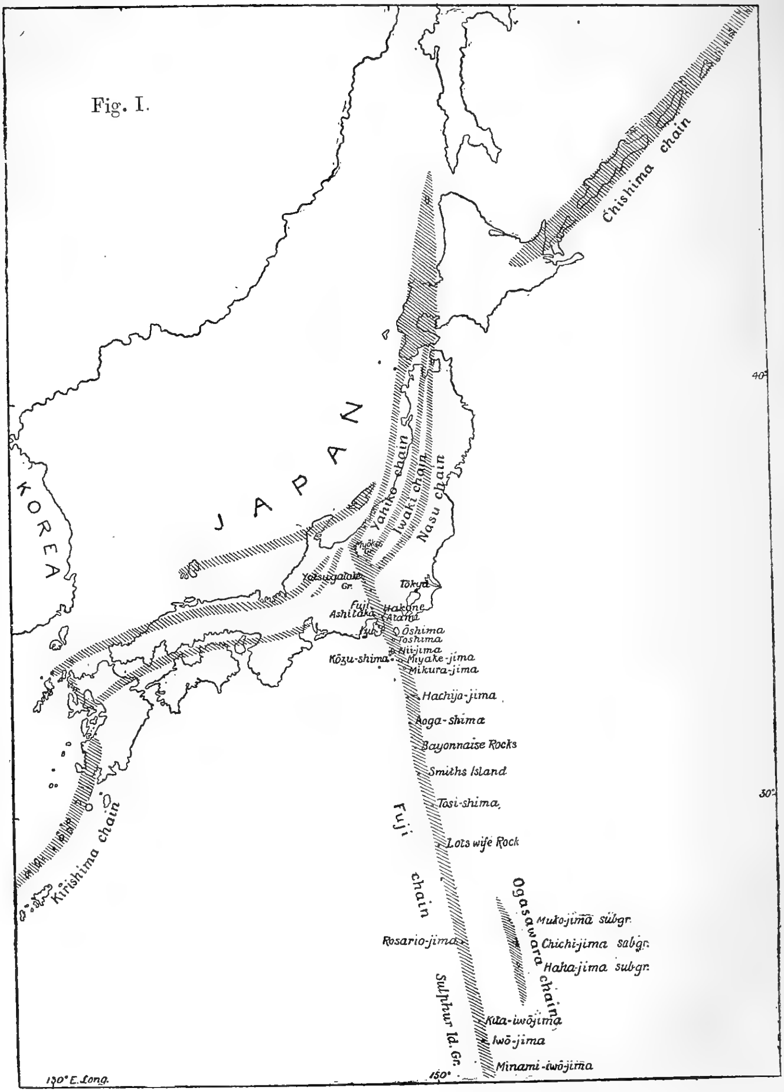
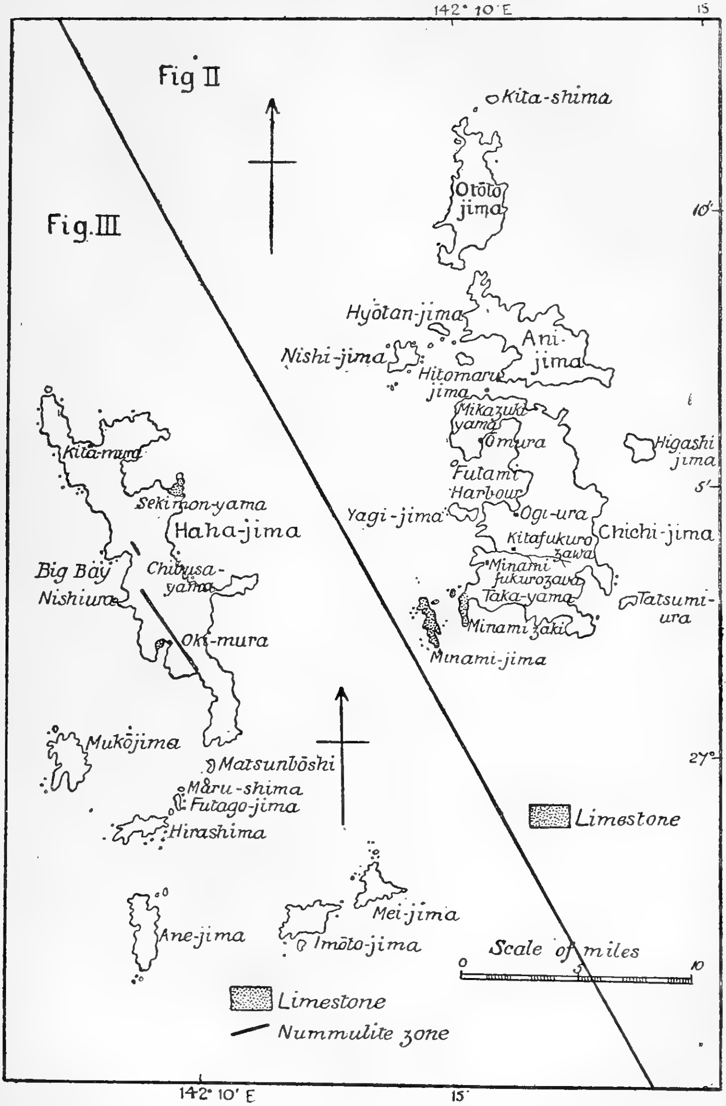


Fig. I.—To illustrate the Neo-Volcanic Chains of the Japanese Islands.

The shaded portions indicate lines of volcanic disturbance.



Maps of Parts of the Ogasawara Chain, or Bonin Islands.

Fig. II.—The Chichi-jima Sub-group.
Fig. III.—The Haha-jima Sub-group.

A special interest is connected with the *Nummulites,* which are abundantly found in the tuff and agglomerate tuff of the Ogasawara group. A single specimen of Nummulite was brought in 1899 to Mr. Wakimizu by a student of the Agricultural College, but at that time the relation to the volcanic rocks of the group was not yet known, nor *the occurrence of Nummulites in Japan* discussed by Japanese geologists; thus the subject was one of special interest in my observations. The *Nummulites* are found, as far as I know, only on the south-western side of Haha-jima, viz., at Nankinyashiki, Cocoa-nut beach, Rōsu-dani, Shizuka-dani, Ichinohashi, Sannohashi, and Nenbutsu-tōge. The Foraminifera-bearing tuff of these localities, except the last, belongs to the same horizon and shows a westerly dip (Fig. 3). In some places the rock is found at a few hundred feet above the sea-level, with a thickness of from 30 to 40 feet. That of Nenbutsu-tōge, only, is found at a height of more than 600 feet, and its relation to that in other localities has not yet been ascertained.

Our *Nummulites* are of two distinctly different sizes. Millions of the smaller form a rock closely cemented together with a tufaceous material. Their diameter and thickness scarcely exceed 5·5 mm. and 2·6 mm. respectively. They are identical with *Nummulites baguelensis* of Verbeek[1] from the Eocene of Java. The larger specimens are again separable into flatter and thicker forms. The thicker ones are identical with *Nummulites javanus,* Verbeek,[1] from the Eocene of Java, and attain a thickness between those of var. β and γ of Verbeek. The flatter ones, which belong to either a variety of the other form or to a quite different species, are very large; the largest collected by me has a diameter of 60 mm., and is probably one of the most gigantic *Nummulites* in the world. On the same horizon as that of the characteristic Foraminifera I found in the tuff of Nishi-ura, near the above-mentioned localities, *Schizaster, Pecten,* a large *Nerita* (somewhat allied to *N. schmedeliana,* Chem., abundant in the Eocene Nummulitic formation of India), besides less numerous forms as *Voluta, Cardium, Tapes, Natica, Dentalium* (?), *Vermetus, Trochus* (?), another species of *Nerita,* two forms of *Ostrea,* and many species of corals. I have collected, besides, complete specimens of three species of *Lithothamnium* from the same place. In the tuff of Oki-mura, lying a little below the strata of Nummulite-tuff, there are many forms of sharks' teeth, representing at least three different species of *Lamna,* together with a few specimens of *N. baguelensis* and *N. javanus.* It is very noticeable that the Nummulite-tuff is evidently intercalated in the lava-sheets or agglomerate tuff, and some large andesite blocks are sometimes enclosed in the tuff as at Rōsu-dani. In Haha-jima I could not find any sign of difference of age to subdivide the rocks of volcanic origin. Thus, all the andesites as well as tuffs of Haha-jima and the other islands of the Ogasawara group must have been formed in the Eocene epoch.

[1] Verbeek et Fennema: "Description géologique de Java et Madoura," t. ii (1896).

Andesite and tuff are the chief rocks composing the Ogasawara group. The latter are always inclined in various directions, showing great disturbance after their formation. We find great limestone exposures, resting in quite horizontal layers, in some parts of the Haha-jima and Chichi-jima sub-groups. The high hill of Sekimon-yama in Haha-jima is entirely formed of this rock, which is besides found in separate areas at Oki-mura and Akaiwa (Sankaku-iwa). In Chichi-jima the same limestone forms the southern point of land called Minami-jaki, as well as Minami-jima and many neighbouring rocks. The limestone is always in elevated places, especially that of Sekimon-yama, which is found at a height of about 800 feet above sea-level, and forms two successive vast terraces along a hill of agglomerate tuff which is about 100 feet higher than the limestone plateau. Here the limestone extends towards the interior for a few miles, and was originally an elevated coral reef. *Lithothamnium*, Bryozoa, and corals are predominant in the limestone. Numerous *Orbitoides* are also found in the same rock at several places. In Minami-jima I found at least three species, one of which is very thin, with the very large diameter of 47 mm. In Oki-mura in Haha-jima, at least three species of small *Orbitoides* were also collected. A few individuals of one small species have been taken from the limestone of Minami-zaki. All the *Orbitoides* above mentioned belong to *Lepidocyclina*;[1] some of them are identical with those from the Miocene of Java described by Verbeek. Thus the submarine volcanic eruption of the Ogasawara group began in the Eocene epoch, and had already ceased before the Miocene. This old volcanic chain must therefore be separated from the Fuji chain, which is younger Neogene or partly even still younger in origin. For the old chain I propose the name of "Ogasawara chain." No indisputably Eocene volcanoes corresponding to the age of this chain have yet been found in Japan, especially near the Fuji chain.

The Fuji chain certainly extends as far as Hachijō-jima. On its south there are, in a line with the Fuji zone, the islets of Aoga-shima, Bayonnaise Rocks, Smith's Is., Tori-shima[2] (Ponafidin Is.), and Lot's Wife Rock, all of which are composed of andesite rock. No land is found between the last islet and the Ogasawara group. When we examine on a map the relative positions of the islands near the Ogasawara group, we find them in two rows. The first row passes from the sub-group of Muko-jima to that of Haha-jima in a line from north to south, at the longitude of about 142° E. The other islets, viz. Rosario-jima on the west of the Ogasawara

[1] Localities of *Orbitoides* in Japan had been confined to Nakakosaka in Province Kōtsuke and Kawaguchi in Province Kai, prior to my journey to Formosa and Riukiu (Loochu) Islands in 1899. Specimens found in Nakakosaka have been determined by Jones as *O.* (*Discocyclina*) *dispansa*, Sow., but afterwards as *Lepidocyclina* by Verbeek. I collected numerous specimens from the limestone in Iriomote-jima in Riukiu (Journ. Coll. Sci. Imp. Univ. Tōkyō, vol. xvi, pt. 1, art. 2, 1901). By my latest researches I am convinced that all these *Orbitoides* of the above three localities belong to *Lepidocyclina*. Besides, Messrs. R. B. Newton and R. Holland found a species of *Lepidocyclina* (*O. Verbecki*, Newt. & Holl.) in a slide of Formosan limestone (Journ. Geol. Soc. Tōkyō, vol. vii, No. 81, 1900).

[2] Spelt Tosi-shima on map, Fig. 1, p. 298.

group and the islands of the Sulphur Is. group, all of which are also of neo-volcanic origin, are arranged in a different direction at about 141° E. (Fig. 1). The second series will be a continuation of the Fuji chain, as proved by the following evidence. Firstly, the Ogasawara chain was constructed in the Eocene epoch; the other chain belongs to a very late formation. Secondly, the second chain lies exactly upon a line drawn from Mt. Fuji over Hachijō-jima as far as Lot's Wife Rock. Thirdly, the volcanic activity of the Fuji chain is of a later date and is not yet extinguished, as shown in the active volcano of Oshima; eruptions frequently take place on the islands south of Hachijō-jima as well as on those to the north. From record we find eruptions took place on Hachijō-jima in 1487, 1518, 1522, 1605, and 1651, and on Aoga-shima in 1652, 1670, 1780, 1781, 1783, and 1785. Violent submarine eruptions occurred till 1889 on the north-west of Kitaiwō-jima, by which the water was raised several hundred feet above the sea-level. Even at the present day we find there muddy sea-water constantly disturbed. The solfataras in Iwō-jima are still constantly active. On the contrary, no volcanic activities are at present observed on the Ogasawara chain. The regions traversed by the Fuji chain are famous for hot springs, which are also seen in the islands on the southern part of the chain, namely, in Hachijō-jima at Kashidate-mura, and on Mihara-yama. In Aoga-shima and Iwō-jima hot springs are said to be everywhere found by digging into the ground. No island of the Ogasawara group has springs either hot or cold. Earthquakes are frequent on the Fuji chain, but not so in the Ogasawara islands. The Fuji chain shows many local disturbances. For instance, Iwō-jima is now being raised up so very quickly, that ground measuring a few hundred yards was upheaved above the sea-level in a few years. Very young-looking reef-corals are now seen on the plateau about 300 feet above sea-level. The islands in the Ogasawara chain have no sign of new upheaval; no coral reefs, excluding those of Miocene age, being there raised above the sea-level even at low tide.

Thus I come to the following conclusions:—

Running parallel to the Fuji chain in the southern sea is another chain, which I propose to name the "Ogasawara chain."

The latter was formed by submarine volcanoes begun in the Eocene epoch and already in repose before the Miocene, while the other chain is of much later date.

The Ogasawara chain shows andesite and variously inclined agglomerate tuff, both covered with a thick horizontal Miocene limestone layer of coral origin. Thus the several disturbances of the volcanic rocks and tuffs preceded the formation of reefs now found as elevated reefs along the ancient sea-coast.

The Fuji chain was formed either simultaneously with or very near the latter part of the formation of the Japanese Islands. The existence of the still older Ogasawara chain shows that there existed already an old weak line of the crust, parallel to and close by the Fuji chain, before the formation of the Japanese Islands.

Fig. 1.—The Neo-Volcanic Chains of the Japanese Islands (p. 298).

Chishima chain.	Yahiko chain.	Nasu chain.
Fuji chain.	Iwaki chain.	Ogasawara chain.
Kirishima chain.		
Myokō group.	Kōzu-shima.	Kita-iwō-jima.
Yatsugatake group.	Miyake-jima.	Iwō-jima.
Fuji.	Mikura-jima.	Minami-iwō-jima.
Ashitaka.	Hachijō-jima.	Tōkyō.
Hakone.	Aoga-shima.	Muko-jima sub-group.
Atami.	Bayonnaise Rocks.	Chichi-jima sub-group.
Izu.	Smith's Island.	Haha-jima sub-group.
Ōshima.	Tori-shima	Izu-shichitō.
Toshima.	Lot's Wife Rock.	Ogasawara group.
Nii-jima.	Rosario-jima.	Sulphur Island group.

Fig. 2.—The Chichi-jima Sub-group (p. 299).

Kita-shima.	Chichi-jima.	Kitafukurozawa.
Otōto-jima.	Mikazuki-yama.	Minami-fukurozawa.
Ani-jima.	Ōmura.	Taka-yama.
Hyotan-jima.	Futami Harbour.	Tatsumi-ura.
Nishi-jima.	Hatsune-ura.	Minami-zaki.
Hitomaru-jima.	Ōgi-ura.	Minami-jima.
Higashi-jima.	Yagi-jima.	

Fig. 3.—The Haha-jima Sub-group (p. 299).

Haha-jima.	Nishi-ura.	Hira-shima.
Kita-mura.	Okimura.	Mukō-jima.
Sekimon-yama.	Matsun-bōshi.	Ane-jima.
Big Bay.	Maru-shima.	Imōto-jima.
Chibusa-yama.	Futago-jima.	Mei-jima.

IV.—List of Thomas Say's Types of Maryland (U.S.) Tertiary Mollusca in the British Museum.

By R. Bullen Newton, F.G.S.

To those students interested in the palæontology of Maryland, United States, it may be welcome intelligence to know that the "John Finch Collection" of Tertiary Mollusca from that State, including some of the type-specimens figured and described by Thomas Say[1] in 1824, is in the possession of the British Museum. This fact has only recently been recognized through the examination of certain documentary evidence connected with the history of the fossil invertebrate collections contained in that institution.

During the early days of palæontological science it is quite apparent that types were not valued as they are now, for the specimens under consideration have escaped anything like proper recognition up to the present time. Without registration numbers and without labels, therefore, considerable care has had to be displayed in selecting from the extensive series of American Tertiary shells in the Museum those particular forms which agreed with the descriptions and figures of Thomas Say. The importance of these types can scarcely be over-estimated, since they form the material on which was based the first systematic description of Maryland Tertiary Mollusca. The collector, John Finch, was himself a professor of geology and an authority on the Tertiary deposits of the

[1] "An Account of some of the Fossil Shells of Maryland": Journ. Acad. Nat. Sci. Philadelphia, 1824, vol. iv, pt. 1, pp. 124–155, pls. vii–xiii.

United States, having written a paper entitled "Geological Essay on the Tertiary Formations in America" (Amer. Journ. Sci., 1824, vol. vii, pp. 31–43), besides some further works on kindred subjects. His last publication, issued in 1833, embraced his "Travels in the United States and Canada" (8vo, London), where references are made to the geology and mineralogy of those countries.

According to official documents, Mr. Finch offered his collection for purchase to the Trustees of the British Museum through Dr. Charles König, who was then the chief officer of the Natural History Department. This offer was accepted, and on the conclusion of the usual preliminaries the collection became the property of the Museum at the close of the year 1834.

Unfortunately the whole of the types have not yet been rescued; some, of course, may never be found, whilst others may come to light hereafter which have by mistake or chance been placed into wrong drawers. In any case it is a fair matter for congratulation that, after a period of 78 years since they were first described, a goodly number of these types are still preserved in excellent condition and are now available for the specialist to study.

With regard to horizons it may be mentioned that, with one exception, the species are of Miocene age, and belong to the Chesapeake formation (see Professor W. B. Clark's "Physical Features of Maryland" in the Maryland Geological Survey Report, 1897, p. 197); the exception is that of *Ostrea compressirostra*, which belongs to the Pamunkey formation, and is therefore Eocene. The nomenclature adopted in the list corresponds with the original as used by Say in 1824, without any attempt at revision.

List of Thomas Say's Types of Maryland Tertiary Mollusca described in the Journ. Acad. Nat. Sci. Phil., 1824, vol. iv, pp. 124–155, pls. vii–xiii, in the British Museum, arranged in the order of original description:—

Species.	Plate.	Figure.	Page.
Buccinum porcinum	vii	3	126
Buccinum aratum	vii	4	127
Dispotæa (gen. nov.) *grandis*	vii	6	130
Fissurella redimicula	viii	1	132
Ostrea compressirostra	viii	2	132
Pecten Jeffersonius	ix	1	133
Pecten Clintonius	ix	2	135
Pecten septenarius	ix	3	136
Plicatula marginata	ix	4	136
Arca arata (left valve only)	x	1	137
Arca centenaria (right valve only)	x	2	138
Arca incile (left valve only)	x	3	139
Pectunculus subovatus	x	4	140
Crassatella undulata	xi	2	142
Isocardia fraterna	xi	1	143
Lucina contracta	x	8	145
Lucina anodonta	x	9	146
Cytherea convexa (right valve only)	xii	3	149
Amphidesma subovata (right valve only)	x	10	152
Panopæa reflexa	xiii	4	153
Dentalium attenuatum	viii	3	154

The types at present missing from this collection are :—

SPECIES.	PLATE.	FIGURE.	PAGE.
Turritella plebeia	vii	1	125
Natica interna	vii	2	125
Fusus 4-costatus	vii	5	127
Fusus cinereus	vii	7	129, 410
Pecten Madisonius [1]	—	—	134
Arca arata (right valve)	x	1	137
Arca centenaria (left valve)	x	2	138
Arca incile (right valve)	x	3	139
Nucula lævis	x	5	141
Nucula concentrica	x	6	141
Venericardia granulata	xii	1	142
Tellina æquistriata	x	7	145
Lucina subobliqua (described, not figured)	—	—	147
Lucina cribraria	xiii	1	147
Venus deformis	xii	2	148
Cytherea convexa (left valve)	xii	3	149
Astarte undulata	ix	5	150
Astarte vicina	ix	6	151
Amphidesma subovata (left valve)	x	10	152
Corbula cuneata	xiii	2	152
Corbula inæquale	xiii	3	153
Serpula granifera	viii	4	154

V.—OCCURRENCE OF RADIOLARIA IN GONDWÁNA BEDS NEAR MADRAS.

By A. K. COOMÁRASWÁMY, B.Sc., F.L.S., F.G.S.

(PLATE XVII, Figs. 1–6.)

THE Upper Gondwána (Rajmahál Series) beds near Madras are divided into two groups, the lower of which has been named from Sripermatúr, a town 25 miles west-south-west of Madras, and a well-known locality for fossil plants. The group is composed of white and pale buff-coloured shales containing plants, at least 10 feet in thickness, resting upon sandstones, grits, and micaceous sandy shales, at least 15 feet in thickness, whose base is not seen, but which probably rest on the gneiss. Silicified wood occurs in some of the gritty beds. The other fossils occur in the shales, and consist of plant and animal remains. The latter are poor, and comprise two or three indeterminable species of ammonites and several lamellibranch bivalves.

Last year, while staying at Madras I paid a short visit to Sripermatúr, accompanied by Mr. Ranga Chari, M.A., of the Madras University. I did not obtain many plant-remains, but was struck by the very porcellanic character of the shales containing them. These are thin-bedded, white to cream or pale coffee-coloured, and often have a smooth conchoidal fracture. A few specimens were collected from a wayside exposure, on the track between Sripermatúr and Vellum. In the thin slices cut from these specimens Radiolaria are to be seen, though for the most part in a very poor state of preservation. These organisms, together with tiny fragments of clastic quartz, and rarely a few carbonaceous specks, are embedded in a fine siliceous paste which remains dark between crossed nicols. Quite locally chalcedonic patches show a fibrous structure. The

[1] This species is described without a figure: the type is said to be in the Museum of the Academy of Natural Sciences, Philadelphia.

fragments of clastic quartz are rarely as large as the Radiolaria, and graduate downwards to the finest dust. Very minute bedding is clearly seen in the slides. The finer material seems to contain, or to be aggregated into, small globular masses, some of which are rather conspicuous, but very possibly not of organic origin.

Dr. Hinde has very kindly examined the slides, and says "there can be no doubt that the organisms are radiolaria." "Probably several forms are present, most of them rounded or lens-shaped discs with minute reticulate structure and without radial spines; others are oval with spines, and one form is like a sugar-loaf in section." In some cases there is a body with reticulate structure within a clear circular area; this may indicate the presence of radiolarian forms with the inner test better preserved than the outer.

There are also in the slides some groups of small rounded bodies, of inconstant dimensions, which, as stated above, are probably not of organic origin. Dr. Hinde thinks that the disc or lens-shaped forms with reticulate structure (Figs. 5, 6), which are by far the most abundant forms present, belong to the genus *Spongodiscus* in the Discoidea section. The conical perforate form (Fig. 4) probably belongs to the genus *Dictyomitra* in the Cyrtoidea division. The spined forms (Figs. 1–3) are too faintly shown for determination, but may belong to the Discoidea section.

The association of these radiolarian forms with plant-remains (the shales are known as plant-beds, though the plant-remains are not very abundant; I found no mollusca myself) is of great interest, as the shales must have been deposited in *comparatively* shallow water, a state of things also indicated by the detrital character of the other beds included in the Sripermatúr group. The shales cannot, however, have been formed very near the shore. Mr. Foote says that they "show every evidence of having been deposited in perfectly tranquil water at sufficient depths probably to be beyond the agitation of the waves. The fragmentary nature of the fronds and leaves appears to indicate that they were drifted out to sea" (Mem. Geol. Surv. India, vol. x, p. 64, 1873). The most porcellanic shales seem to contain the best preserved plants.

The Radiolaria must have been present in sufficient quantity to give a very siliceous character to the rock, yet the use of the term 'radiolarian chert' would hardly be justified. I might add that Radiolaria are to be found at the present day in shallow water, though not in such abundance as in the open ocean.

Finally, I desire to thank Dr. Hinde for his very kind assistance and advice.

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Paleont. Indica, ser. ix, p. 236, 1875.
Geology of India, 2nd ed., pp. 182, 208, 1893.

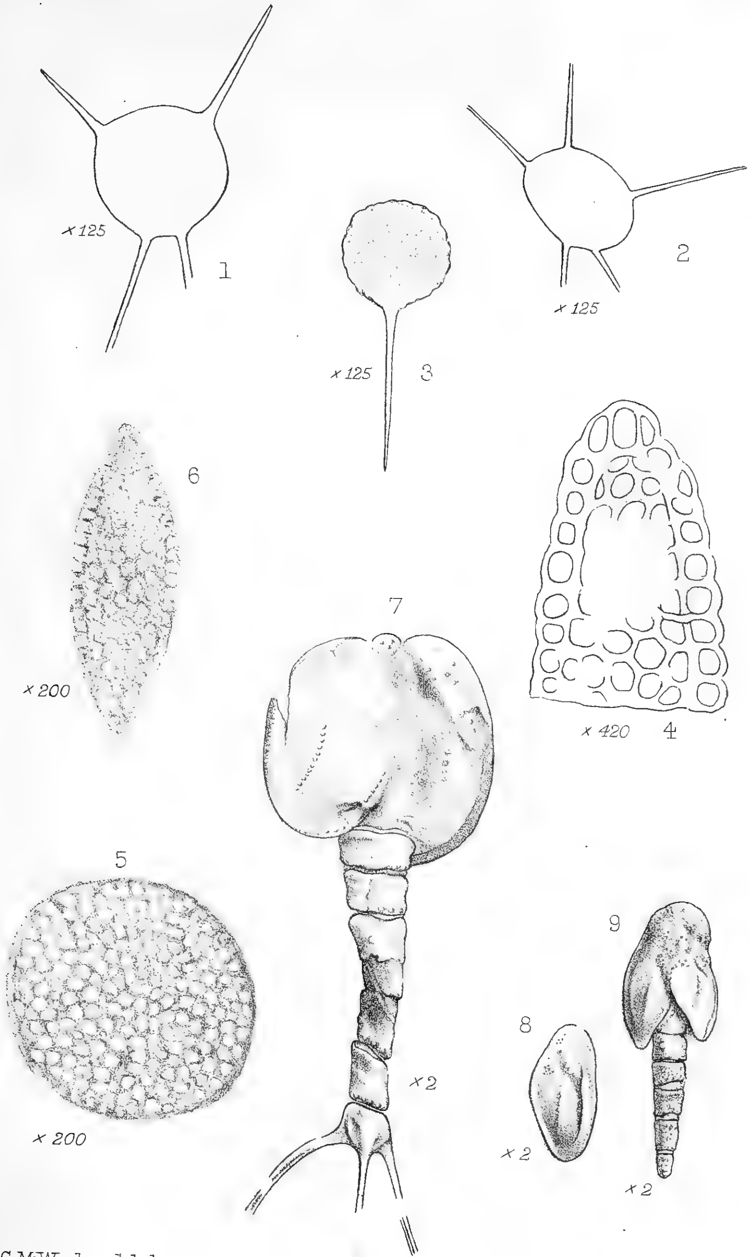
EXPLANATION OF PLATE XVII.

Radiolaria from Upper Gondwána Beds, Sripermatúr.

Figs. 1–3.—Spined forms, possibly belonging to the section Discoidea; outlines only distinguishable; × 125.

Fig. 4.—Conical reticulate form probably referable to the genus *Dictyomitra*, × 420.

Figs. 5, 6.—Lenticular reticulate form perhaps belonging to the genus *Spongodiscus*, × 200.



G. M. Woodward lith.

West, Newman imp.

Figs. 1–6. Radiolaria, *from Madras.* Figs. 7–9. Echinocaris, *from Devonshire.*

VI.—*Echinocaris Whidbornei* (Jones & Woodward) and *Echinocaris Sloliensis*, n.sp.

By Miss E. M. Partridge.

(PLATE XVII, Figs. 7–9.)

DURING the last year the Marwood Beds of Sloley Quarry, near Barnstaple, have yielded some additional specimens of *Echinocaris*, which have afforded material for the present note. The specimens have all been found in the fine micaceous shaly beds, six to eight feet thick, on the north side of the quarry, below the massive sandstones, and above the shallow-water bed containing plant-remains, rain-prints, worm-tracks, etc. The same shaly beds contain *Lingula squamiformis* in abundance; other bivalves are less frequent. They have now yielded as many as twelve specimens of *Echinocaris*.

Echinocaris Whidbornei (Jones & Woodward).

One of the recently discovered specimens (Fig. 7) is more complete than any hitherto found. The *carapace* is much crushed. The six *abdominal segments* are well preserved; the abdomen tapers posteriorly. The segments increase in length towards the posterior segment, the anterior somites being twice as long as wide, the posterior somewhat less wide than long. The posterior margins of the segments are furnished with nodes or short spines, those of the two anterior segments being small and few in number. The four posterior segments have also one or two short nodes or spines on the dorsal or lateral surface. *Telson* smooth, slightly smaller than the last abdominal segment, triangular in outline, produced into a long slender spine quite twice as long as the posterior abdominal segment. Ventral surface of this spine with a central furrow, shown on the mould as a ridge, where a portion of the spine has been broken away. Attached below the telson are two other spines, which are slightly longer than the spiniform extension of the telson. These spines also have a central furrow along the ventral surface.

Measurements: Abdomen, 18 mm. long; segments, commencing with the anterior, respectively about 2, 2·2, 2·7, 3 (?), 3, 4 mm. in length; telson, 2 mm. long by 2·5 wide; telson and spine, when complete, together 10 mm.

Echinocaris Sloliensis, n.sp.

The description is based on two specimens (Figs. 8, 9), for one of which I am indebted to Mr. F. J. Partridge, who discovered it. The other was found by Mr. A. K. Coomáraswámy. Neither specimen is complete, nor are they very well preserved. *Carapace* convex, elongate-ovate in outline, the valves about twice as long as broad, or more. Margins thickened, carinated, but wider and flattened at the posterior ends of the valves, which ends are rather widely separated. Cephalic region not well preserved in either specimen; the cephalic swellings similar to those of *E. socialis* (Beecher). The thoracic portion of the valve possesses two ovate tubercles, one (the smaller) parallel with the outer margin and situated in the upper outer corner of the thoracic portion of the valve; the other is situated transversely, and found in the upper dorsal portion near the hinge. Along the outer margin of the first tubercle runs, parallel with the margin and towards the posterior angle of the valve, a sharp, almost smooth carina; at its upper end it bends outward to the ventral margin of the valve. From the other tubercle runs a second, nodose ridge, almost coinciding with the dorsal line, and continued along the margin of the valve. In the centre of the area enclosed by these two ridges is a longitudinal row of minute nodes, ornamenting a third carina. The other elevated portions of the valves possess also minute irregular tubercles, but the outer carina is almost or quite free from these. *Abdomen* composed of six visible segments (the telson being absent in our specimens), the whole tapering, the posterior segments a little longer than the anterior. The posterior margins of each segment are ornamented with a number of small nodes, the anterior segments possessing fewest of these. A few tubercles are also found on the surface of the segments between the posterior and anterior margins.

Measurements: Length of valves, 9–10 mm.; greatest width of a single valve, 4·7 mm.; abdomen, 11 mm. long.

This species much resembles *E. socialis* (Beecher), but the carapace is much longer in proportion to its width. The outer carina also is almost or quite smooth, and bends outward to the ventral margin of the valve instead of fusing with the tubercle as in *E. socialis.* The middle carina is also more prominent than in *E. socialis.*

I am much indebted to Dr. Henry Woodward for kind assistance and advice in the preparation of this note.

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EXPLANATION OF PLATE XVII.

Echinocaris from the Marwood Beds, Sloley Quarry, near Barnstaple.

Fig. 7.—*Echinocaris Whidbornei* (Jones & Woodward). Partridge Collection. × 2.

Fig. 8.—*Echinocaris Sloliensis*, n.sp., right valve of carapace. Coomáraswámy Collection. × 2.

Fig. 9.—*Echinocaris Sloliensis*, n.sp., another specimen, more complete. Partridge Collection. × 2.

VII.—Monzoni and Upper Fassa.

By M. M. Ogilvie Gordon, D.Sc.

THE following pages present some results obtained by me from the geological survey of the Fassa district in the Dolomites comprising the Bufaure and Monzoni mountain groups, where the porphyritic and monzonitic rocks are widely exposed. In selecting this district I had two objects in view—(1) to study in detail the tectonic relations between the igneous and stratified rocks; (2) to test the results which I had previously obtained from my survey of Sella Massive, etc.

The Tertiary Age of Monzoni.

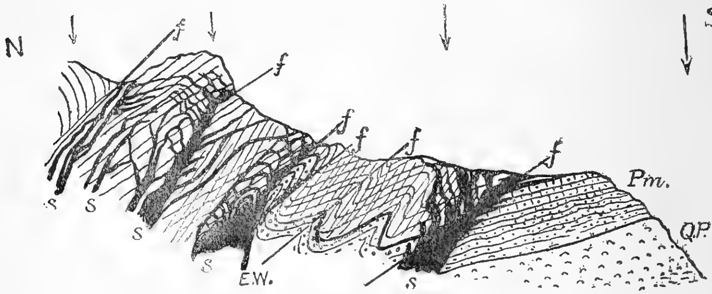
The Campagnazza Meadowland stretches east of Monzoni as undulating slopes descending southward from the Costabella range of limestone to the Pellegrino Valley. The meadowland is composed of Permian and Werfen strata, and I discovered in it a number of intrusive sills of porphyrite associated with two faults. The more northerly of the faults runs east-west at the southern base of the Costabella range, and it continues westward as the northern fault-limit of the Allochet ridge and Monzoni. This fault is steeply inclined to the north, and the differential movements have effected the relative downthrow of the Costabella fault-block on the north. The other fault follows a curved strike, its course being E.S.E.–W.N.W. in the Campagnazza, but curving to E.N.E.–W.S.W., where it is continued as the southern fault-limit of the Allochet ridge and the monzonite rocks of Monzoni. The curvature is convex towards the north, and the fault-plane is inclined northward. In the Campagnazza there is north of the fault a crumpled sheared slice of Werfen strata; but this block is represented at Monzoni by the intruded igneous rocks. The tectonic relation of the monzonite intrusion is therefore that of a fault-sill, representing in the strike the Campagnazza crust-slice between the two faults, and injected at an angle of strike-curvature.

The fault-block south of the curved fault may be conveniently termed the Pellegrino fault-block. It comprises quartz porphyry, Permian strata, and fault-fragments of Werfen strata, and has been driven southward, representing one of a series of overthrust slices which occur south of the Pellegrino Valley (Fig. 1).[1] Still farther south the Cima d'Asta overthrusts are present, and as there are occurrences of Jurassic and Cretaceous strata in the shear-zones of the overthrust faults, it is clear that the slicing took place in connection with Tertiary movements in the Alps. The Campagnazza fault-curves were certainly not earlier than the overthrusts; thus, my geological mapping, which proves the replacement of the Campagnazza sheared slice by the monzonite intrusion, proves at the same time that the intrusion was of Tertiary age. I find further that I can offer an interpretation of the sequence of injections

[1] I have made no personal examination of the district south of the Pellegrino Valley.

in the Monzoni mountain based upon the details of strike-cleavage in the Campagnazza Meadowland and Monzoni.

The Costabella downslip slice strikes N. 75°–80° W., the Campagnazza shear-slice strikes N. 65° E., the Pellegrino thrust-slice strikes N. 65°–80° W. These facts indicate that the proximal crust-slices have adjusted themselves in the Campagnazza along different strikes, the one being the differential correlative of the other. But at Allochet the strike both of the Costabella and Campagnazza crust-slices curves to the E.N.E.–W.S.W. direction, and the monzonite rocks of Monzoni have this as their fundamental strike, the dip-cleavages being towards the north-west at an angle of ca. 50°, and towards the south-east at an angle of ca. 40°. The E.N.E. and W.N.W. strikes may both be suitably termed 'Asta' strikes, from the famous Cima d'Asta Massive in the Dolomites, where Professor Suess first determined overthrust movement towards the S.S.E.



Transverse section through the Costabella range (Middle Triassic limestone); the Campagnazza Meadowland (Lower Triassic mixed deposits and fault-fragments of Permian strata); the slopes of Pellegrino Valley (Permian strata (*Pm.*) and Quartz Porphyry (*Q.P.*)); *f f*, 'Asta' faults; *E.W.*, old east-west fault; *s s*, porphyrite sill and dyke system ascending faults, cleavage-planes, and bedding-planes.

In my previous papers I have demonstrated that these correlative strikes developed in consequence of the superposition of the Peri-Adriatic movements upon the regional East Alpine movement, and this explanation is fully borne out in the Campagnazza. The east-west fault north of Monzoni and the Campagnazza is, according to my researches, an old synclinal fault between two fundamental East Alpine anticlines, that of the original Pellegrino anticline on the south of the fault, and on the north of it the anticline which I shall term the Contrin anticline, from its favourable exposure on the Contrin Alpe north of the Costabella range.

The north fault-limit of Monzoni with east-west direction has in previous literature gone by the name of the 'eruptive fissure,' and probably the direction of this fault gave the erroneous impression that the monzonite had a parallel strike. But the monzonite rock both here and in the Predazzo area, a little to the south-west of Monzoni, strikes E.N.E.–W.S.W., and as will appear from what follows, the original intrusion of monzonitic magma was a continuous

'Asta' fault-sill—the western or Predazzo portion having been *subsequently* displaced southward, and downthrown relatively to the Monzoni portion. Again, the 'eruptive fissure' has been described as "probably" continuing through a porphyrite fault-dyke east of Lago di Selle and passing E.N.E. through the Costabella range. This is, however, not the case. The east-west fault holds its own direction, passing due east into the Campagnazza. I regard it as one of the leading Alpine faults in this district, comparable with the Gröden and Buchenstein faults which I have described in my former papers. Its age *may* be far greater than the injection of the monzonite, seeing that the injection was synchronous with the superposed 'Asta' movement. Moreover, the term 'eruptive' was applied under the conception that Monzoni was a volcanic centre in Triassic time, the monzonite being the deep-seated facies of Triassic surface flows of porphyritic lava and tuff. This I hold to be a mistaken conception, as I have carefully examined all the supposed surface flows of porphyrite in the vicinity of Monzoni and in Upper Fassa, and have found them to be intrusive sills and dykes, injected subsequently to the main intrusion of monzonite, at that epoch in fact when the monzonite fault-sill was cross-sliced, and its western portion laterally displaced as far as Predazzo. According to my mapping of this district there are no igneous *contemporaneous* rocks later than the quartz porphyry except the tuffs in the Wengen-Cassian beds.

Having now pointed out how some of the older misconceptions regarding Monzoni may have arisen, I shall proceed to indicate briefly a few of the leading observations I have made throughout the district.

The Miocene Age of Porphyrite Sills.

Fig. 1 is a generalized transverse section through the Campagnazza Meadowland and the Costabella range. It shows how the two crust-slices, the Campagnazza and the Costabella slices, are themselves cut by subordinate fractures. These are 'Asta' fractures, striking either E.N.E. or W.N.W.; the inclination of all shear-planes is northward, but the angle of inclination varies very considerably. The chief tectonic complications occur in the immediate proximity of the older east-west fault. In the *eastern* or Fuchiade part of the Campagnazza, a small segment of older strata is at this fracture overthrust above Upper Werfen strata. In the *middle* part of the Campagnazza, several porphyrite fault-sills ascend at this shear-zone. The *western* or Allochet portion near Monzoni, like the middle area, shows several shear-planes and porphyrite fault-sills, but the strata dip more steeply. The porphyrite sills run continuously from the 'Asta' faults into virgating cross-faults directed N.N.W.–S.S.E. and N.N.E.–S.S.W. Two virgating groups of faults and fault-dykes divide the Campagnazza into the three segments which I have indicated—the Allochet segment on the west, the middle or main cross-segment, and the Fuchiade segment on the east. The middle segment is an upthrow relatively to the segments east and west of it; the cross-fault limiting it against the Allochet ridge is directed N.N.W. – S.S.E., but the cross-fault limiting it against the Fuchiade segment on the east is directed N.N.E.–S.S.W. Hence the leading strike-curve of the Campagnazza is convex to the north.

The diagonal fault-dykes continue their course northward and cut the Costabella range into similar cross-slices. In the Costabella range the fault-dykes are again continuous with sills which follow the strike, penetrating the strata at various horizons. Two leading sills are fault-sills,—the lower is injected at the horizon of Mendola limestone, the higher is included in a complex shear-zone of Cassian and Schlern limestone horizons. The latter has previously been regarded as the direct continuation of the east-west fault, but it is only one of several branches from the east-west fault, diverging E.N.E. from the Lago di Selle plateau.

The whole rock succession in the Campagnazza and Costabella has undergone vertical cross-cleavage according to a north-east and south-west (N. 40° E.) strike, and inclined cross-cleavage along a N.W.–S.E. direction with the dip-cleavage planes inclined south-east at an average angle of 35°–40°. The intrusions of porphyrite ascend chiefly in the planes of strike-cleavage, and the sills occupy irrespectively the north-dipping bedding-planes and the inclined cleavage-planes with south-east dip. I have incontestible proofs (1) that injections run continuously into the Asta planes and the planes of cross-cleavage; (2) that the cross-cleavage strike and dip system has disjointed and deformed the Asta strike and dip system; and I therefore conclude that the leading porphyrite sills and dykes in this area were coeval with the superposition of the cross-cleavage system. In previous papers I have called the cross-cleavage system the 'Judicarian' system, and referred it to the Miocene geological epoch, treating it as a more advanced phase in the protracted history of superposed movements than that which gave origin to the E.N.E. and W.N.W. strikes. The 'Judicarian' and 'Asta' systems of strike have orthogonal correlation with one another, the N.N.E. 'Judicarian' strike being rectangular to the W.N.W. 'Asta' strike, and the N.N.W. 'Judicarian' strike being rectangular to the E.N.E. 'Asta' strike. Thus cross-cleavage was superinduced upon the 'Asta' strike-system, but the differences in the detailed stratigraphy of the cross-segments in the Campagnazza show that both systems were acting simultaneously, the orthogonal stresses being associated with the superposition of the N.N.E.–S.S.W. or 'Judicarian' strike upon the fundamental east-west 'Alpine' strike.

The Cross-Cleavage of Monzoni.

The 'Asta' injection of monzonite apparently engulfed the stratified rocks of the Permian and Werfen horizons, and as it consolidated did so in conformity with the actual strike and dip of the bedding-planes above, around, and amidst them. The rock-magma, owing to the action of the local pressure-strains, consolidated as a series of gneissose zones, and these original segregation zones have the

E.N.E. strike and northward dip of the whole mass. In succession from south to north the zones are: (*a*) the lowest zone, a light coarse-grained monzonite specially rich in mica; (*b*) a finer-grained differentiation of the micaceous type of monzonite; (*c*) a coarse-grained, pyroxenic, or gabbro-like monzonite; (*d*) a finer-grained dark type, highly augitic; this uppermost zone sends short apophyses into the limestone of the peripheral zone.

Differential movements subsequent to the 'Asta' injection of monzonite have concentrated themselves at the zone between the finer-grained micaceous type and the coarse gabbro-like monzonite. The dip-joints curve steeply northward at this horizon, and the augitic segregation zones have been downthrown to the north and west and sliced by several shear-planes both in strike and cross directions. *The chief fault-zone runs entirely through the Monzoni mountain,* following a curved strike, which, like the Judicarian-Asta fault-system round Allochet and Campagnazza, is convex to the north. The fault-zone through Monzoni is parallel with the peripheral fault-system, limiting Monzoni on the west, north, and east. In the fault-zone the monzonite rock is sheared and slickensided in the very highest degree, having been converted into a monzonite fault-schist, or in some places into a coarser fault-breccia. Moreover, *the fault-zone is the seat of later injections,* in contact with which the earlier gneissose bands of monzonite have endured extreme contact alteration. The later injections have two very important tectonic features in common with the porphyrite sill and dyke system of the Campagnazza. They extend continuously in the strike fault-curve through Monzoni, and in numerous cross-faults (N.N.W., N.S., and N.N.E.) which cut Monzoni into a series of cross-segments comparable with those of the Campagnazza. This feature in itself gives a safe indication that the later injections in Monzoni were, like the porphyrite sills in the Campagnazza, associated with the 'Judicarian' movement. But there is still stronger evidence. The whole of Monzoni has been cross-cleaved, the strike-cleavage being north-east to south-west, and the slabs of dip-cleavage being inclined to the south-east. The cross-cleavage planes of Monzoni are in fact a repetition of those displayed in the stratified rocks of the Campagnazza, and the differential correlative planes are similarly developed. The later injections in Monzoni ascend pre-eminently the vertical cross-cleavage planes or the inclined planes dipping south-east. Thus it may be safely concluded that the later irruptions in Monzoni took place in the Miocene epoch when the Asta-Judicarian movements had reached their most intense phase in the Alps.

The series of later injections includes a much greater mineralogical variety of igneous types than the earlier intrusion. The first injections of the later series include somewhat abnormal augitic and hornblendic types of monzonite and a still more basic olivine-gabbro type, coarsely crystalline for the most part, but passing into basaltic facies. This rock is readily recognized in the leading fault-zone by its characteristic ferruginous and serpentinous decomposition products. It also runs northward as cross-dykes in the rugged spurs that descend to the Monzoni Alpe. Certain peripheral dykes of very basic types of monzonite are also of this period.

The next set of injections show marked differentiation into granitic and augitic varieties. Usually the injections are found in group form, the more acid and more basic types occurring together or within a few yards of one another. Dyke-pairs of granite and porphyrite or of monzonite aplite and hornblendic monzonite are very common, and there are fault-dykes of aplite, pegmatite, or highly felspathic monzonite. Seams of orthoclastic rock are freely injected both in strike and cross directions. Those groups, pairs, or seams of smaller dykes occur across the olivine-gabbro and normal monzonite rocks in Monzoni, and also sporadically at the peripheral shear and contact-zone, where they are very often associated with a fine-grained basic porphyrite that weathers greenish, and answers in its thinner threads to the description of the igneous rock which has passed in the literature under the name of 'pietra verde.'

The last injections include liebenerite porphyry, plagioclastic porphyrite, and some ultrabasic limburgite types. Their occurrence in the field is in north-south direction or very few degrees east or west of this direction. They cross all other dykes; several excellent exposures that I found prove them to be the youngest type of injected rock in Monzoni. They mark certain 'focal areas' within the mountain where strike and cross faults intersect. At these areas local inthrows have occurred in relation to a cross-movement from east to west, whereby cross-slices of Monzoni were overthrust westward, and behind each thrust-slice there was a zone of downslip and inthrow.

The western thrust-slices present an arrangement of gneissose bands following strike-curves convex to the west. This strike-curve is orthogonal to the strike-curve convex to the south, which is characteristic of the front portions of the Pellegrino and other thrust-masses overthrust to the S.S.E. The focal areas around which these transverse or 'Judicarian' strike-curves are arranged occur within Monzoni, but the focal area corresponding to the general strike-curve of the monzonite rocks is immediately north of Monzoni, at an area in Monzoni Alpe where inthrow has taken place, and where the N.N.E., N.S., and N.N.W. cross-faults that radiate through Monzoni converge.

I regard the olivine-gabbro and contemporary basic types of monzonite in Monzoni as the deeper-seated facies of the massive porphyrite sills that spread through the Triassic horizons in the neighbouring districts; whereas the granites, aplites, and the more segregated types of porphyrite and monzonite in Monzoni were coeval with certain fine-grained basic injections into the porphyrite sills of the vicinity.

The occasional ultrabasic dykes in north-south cleavage-planes were still later. In Monzoni, in the neighbourhood of the chief shear-zone, the rocks have been rippled along an east-west strike; in the Allochet ridge east of Monzoni there is rippling in this direction, and cross-rippling due north and south. The wave-length of these ripples is quite short, but as the whole area shows north-south cleavage, I consider them confirmatory evidence that the East-Alpine pressure-system acted intermittently or synchronously with the Judicarian-Asta pressures, and that as these pressures temporarily waned after the epoch of crust-slicing and igneous intrusions, the effects of the East-Alpine movement became more pronounced. Whether this explanation be correct or not, the stratigraphy shows that horizontal compression acted along east-west and north-south directions after the epoch of the most intense Judicarian and Asta movements.

The Contrin and Buchenstein Anticlines.

The Permian and Werfen strata are widely exposed on the Contrin Alpe, and the essential features in the stratigraphy of the anticline are more easily obtained than in the Pocol and Monzoni Alpes farther west. According to my mapping, the original north limit of the Contrin anticline was an east-west fault through the present Bufaure Massive from Mazzin in Fassa Valley to Penia at the confluence of the Upper Avisio and the Contrin streams, the fault continuing eastward through the Upper Avisio Valley, westward through the Udai Valley. The original south limit of the Contrin anticline was the east-west fault north of the Campagnazza and Monzoni area. The present distance between these two faults is, as the crow flies, about $6\frac{3}{4}$ kilometres.

The Contrin anticline is succeeded on the north by another east-west anticline, that of Upper Fassa. It is the continuation of an anticline to which I previously gave the name of the Buchenstein anticline (Q.J.G.S., 1899, p. 583). In Upper Fassa the Triassic strata belonging to this anticline are exposed in the northern half of Bufaure, in the Upper Fassa slopes, in Rodella Mountain, in the slopes of Mount Donna, in the Sella Pass, and in the southern half of the Sella and Langkofl mountain-massives. The old east-west fault which forms the original limit of the Contrin anticline on the north, is the *southern* fault-limit of the Buchenstein and Upper Fassa anticline. The *northern* fault-limit of the Buchenstein anticline, as demonstrated by me in former papers, passes through the Langkofl and Sella limestone-massives, through Stuores Alpe and the north of Sett Sass, being at the same time the southern fault-limit of the Gröden anticline. The distance between the limiting-faults of this anticline in Upper Fassa is the same as the width of the Contrin anticline, viz. $6\frac{3}{4}$ kilometres. Both anticlines have undergone cross-deformation in virtue of the superposed Asta-Judicarian movements. In several cases that I have measured, the width of the complete wave-form of the Judicarian cross-movement is in this locality $5\frac{1}{2}$ kilometres.

The Asta-Judicarian movements have produced a series of over-thrust and downslip crust-slices following strike-curves, and cross-faulted as in the case of Monzoni. The porphyritic sheets have been injected in the downslip shear-zones behind the thrust-masses of Werfen and limestone strata, and in 'Judicarian' cross-faults;

they have locally broken through the thrust-masses as fault-sills and dykes, brecciating and altering the strata, the igneous and brecciose material thus replacing the strata along the strike of the thrust-masses. Accordingly I dissent from the opinion advanced by Mojsisovics and repeated in slightly different form by Salomon, that the igneous rocks of Bufaure, Belvedere, etc., constituted a volcanic Triassic facies of the Marmolata limestone. The massive sheets of porphyrite at Bufaure, etc., are wholly intrusive and run into radial and strike fractures associated with the Asta-Judicarian movements. The stratigraphy of the district will be fully set forth in the geological map and sections that are to accompany my complete paper.

Block-Porphyrite.

Some of the most puzzling problems concerning the mineralogy of the district are associated with the block-porphyrite ('Block-Porphyr' of Mojsisovics), or, as it has been frequently termed, the conglomerate or 'agglomerate' structure of the igneous rocks. The explanations offered by all who have surveyed in this district except myself have been based upon the assumption that the Bufaure and neighbouring sheets of porphyrite were contemporaneous Triassic lavas. During my own field-work I have had to make a close investigation of various sills of block-porphyrite, and find that the conglomeratic appearance is due to various causes. While in many cases the block-structure is simply a result of original segregation in concretionary lumps or lenticular patches and bands, there are others where the structure is superinduced. I found it necessary to determine the joint-cleavage systems in the porphyrite very carefully, as the later, more basic injections have frequently been injected along the joint-planes, and so encircle isolated masses of an earlier sill, just as the sill-magma itself enwrapt or infiltrated particular masses of strata when it was injected. I classify the different types of block-structure as follows :—

(a) *Original agglomeratic structure* dependent upon various forms of segregation products;

(b) *Joint-block structure* due to decomposition and weathering of the porphyrite along intersecting curved joints;

(c) *Superinduced brecciose structure* where a sill has after consolidation been subjected to differential shearing;

(d) *Combination-sill structure*, where intermittent injections have passed into the same fault-zone, and the later injections have broken up the older.

The Sella Pass.

The north wing of the Buchenstein anticline occupies a crust-zone in which old eruptive fissures of Triassic age occurred. I have previously determined the Buchenstein-Mahlknecht fault-zone extending east and west through this area, and have pointed out that the tufaceous as contrasted with the calcareous facies developed in the proximity of, and north of, this Triassic fracture-zone during the

Wengen-Cassian epoch, and that the northern area was especially subject to local variability during the Upper Cassian and Raibl periods (ant. Q.J.G.S. 1893, Geol. Mag. 1894 and 1900, Verhandlungen 1900). In 1900 I prepared a transverse section through Sella Pass on the north of the fracture-zone, according to which the stratigraphical succession is as follows:—(1) *Wengen* tuffs and shales with the typical plants and bivalves; (2) *Cassian* limestones, marls, tufaceous shales and grits, containing the typical Stuores-Cassian fauna together with *Pachycardia rugosa* and several other species found at Seiser Alpe, but not, so far as yet known, at the Stuores locality near St. Cassian; (3) Upper Cassian limestones and tufaceous marls and breccias; the 'Cipit-Kalk' or reef-limestone lenticles are imbedded in tufaceous rocks containing a transitional Cassian-Raibl fauna, and passing conformably under the Schlern-dolomite rocks of the adjacent mountain-massives. At Sella Pass numerous specimens of *Pachycardia rugosa* occur at both the Cassian zones; on the other hand, certain forms such as *Trigonodus Rablensis* and certain species of *Avicula* make their first appearance in the Upper Cassian zones. The rich fauna found in the 'Pachycardia tuffs' of the Seiser Alpe (v. Zittel, Zeitschrift, 1899) is very well represented at Sella Pass. And comparing my Sella Pass section with my former sections in Enneberg and Ampezzo, the 'Pachycardia tuffs' are demonstrated to be *the time-equivalent of the whole St. Cassian series.*

It has previously been supposed that the Wengen-Cassian series were absent in Fassa, but I have found that although thinly developed, the Wengen and Stuores-Cassian zones are present at the base of the Vallaccia limestone massive between Fassa Valley and Monzoni, and at the base of the Punta di Costabella.

REVIEWS.

Om de Senglaciale og Postglaciale Nivåforandringer i Kristianiafeltet (Molluskfaunan). Af W. C. Brögger, med Bidrag af E. B. Münster, P. Öyen, o. pl. Med 19 plancher og 69 figurer i Texten. Norges geologiske undersögelse, No. 31. (Kristiania: H. Aschehoug & Co., 1900 og 1901.)

On the Late Glacial and Post-Glacial Changes of Level in the Christiania Region. By W. C. Brögger, with contributions by E. B. Münster, P. Öyen, and others. Norwegian Geological Survey, No. 31. 8vo; pp. 731, 19 plates, and 69 figures in the text.

THE changes which Norway has passed through in the concluding portions of the Glacial period and subsequently to the present time, have not been so systematically and thoroughly investigated as those in the eastern portion of the Scandinavian peninsula, and though various branches of the subject have been described during the last fifty years the Norwegian geologists have not, as a rule, specially concentrated their researches on this part of the geological history of their country. This circumstance moved Professor Brögger, although, in his own estimation, no specialist in the field of glacial geology, to trace out in detail the important series of changes which accompanied and followed the retreat of the last great ice-sheet which covered Southern Norway. Nowhere are the records of these changes better preserved and more clearly shown than in the districts bordering the Christiania fjord, a region which the author has already made classical by his well-known description of its Palæozoic geology and fossils.

Although the title of the work refers to the changes of level which the country has undergone in the period under consideration, the evidence of these, to a great extent, is furnished by the characters of the molluscan fauna in the various deposits, and the work gives mainly the results of a detailed study of the changes which have taken place in this fauna by the introduction of certain species and the disappearance of others. Not only changes of level but modifications of the climate are also indicated by the various phases of the molluscan life which flourished in the Christiania fjord after the retreat of the ice-sheet.

The author treats the subject under three main divisions or periods. The first of these—the period of subsidence—begins at a time when the front of the glacier extended across and on both sides of the southern portion of the Christiania fjord, and in front of it huge terminal moraines were being formed beneath the sea-level, while outside of these the Yoldia-clays were laid down. The level of the land at this time was not much lower than at present, but a movement of depression had set in which continued until the land had sunk to the extent of about 240 metres (787 feet), and the sea margins reached to the southern end of Lake Mjösen and the other lakes of Central Norway. During this sinking interval the land-ice was gradually melting back northwards, leaving behind, at successive stages in its retreat, huge ramparts of terminal moraines indicating prolonged pauses in its recession. Over the areas vacated by the ice, beds of shelly clays were deposited; the shells for the most part are of Arctic species, but in the later stages of the depression there was an admixture of boreal forms.

The second period was ushered in by a movement of elevation, and its various stages are shown by the abundance of shelly sands and gravels at different levels above the sea, and to a subordinate extent by clay-beds as well.

The third, or post-Glacial period, commences about the middle of the elevatory stage and continues to the present. It is characterized mainly by shallow-water sands and gravels, with numerous shells and clay-beds as well. The mollusca are now for the most part boreal, and southern forms and the principal Arctic species have disappeared.

I. *The Period of Subsidence.*

Returning now to the late Glacial period of subsidence, the author states that the terminal moraines—or *ras,* as they are designated—

consist of enormous masses of stratified sand and gravel of rolled pebbles, with patches of clay, which have been brought down by the streams produced by the melting ice and deposited beneath the sea-level immediately in front of the glacier. In structure they may be compared to *åsar*, but their position is that of terminal moraines. The outermost *ra* crossing the Christiania fjord has been assumed to represent the furthest extension of the land-ice during the last glaciation of the country, but this is incorrect, for the rock surfaces beyond the ra are glacially striated in the same way as those behind it, and there is no doubt that the ice of the last glaciation reached outwards, beyond the present shore limits of the country.

Outside the terminal ra, that is, between the moraine and the coastline, but never within the morainic barrier, there is a widely spread deposit of clay, known as the Yoldia-clay, which in places rests directly on the striated surfaces of the ancient rocks and in places on the outer slopes of the ra, from below the present sea-level to 40–45 metres above it. The clay consists of a fine mud, often with stones and boulders of porphyry, syenite, and granite, originating from the central and northern portions of the Christiania region; many are typically striated. Molluscan shells of large size, indicating favourable conditions of existence, are abundant in the clay. Twenty-six species have been determined; the commoner and most characteristic forms are *Portlandia* (*Yoldia*) *arctica*, Gray, *Macoma calcaria*, Chem., *Saxicava arctica*, Linn., *Leda pernula*, Müll., and *Nucula tenuis*, Mont. The first of these occurs nearly everywhere; both valves are usually found united, and the epidermis and ligament are preserved. In places the clay contains numerous foraminifera; one species, *Polystomella arctica*, Park. & Jones, is a typically Arctic form. The mollusca of the Yoldia-clay are now all found living in high Arctic regions at depths of 10–30 metres; most of them are present in the Kara Sea, and it may reasonably be assumed that these fossils lived under similar conditions of depth and temperature as their recent representatives. The Yoldia-clay with its characteristic fauna can be traced on the sea-bottom round the coast of South Norway to depths of over 70 fathoms, which shows that during the earlier deposition of the clay the land must have been at a higher level than at present. The shells appeared to have lived contemporaneously with the formation of the outer ra, and the land appears to have sunk during this period from about 50 metres above to 70–75 m. below the present level.

The question of the elevation of the land in Norway before the ra period, during the time of the great glaciation, is discussed by the author in connection with the occurrence of sub-fossil shells, of species which, living, are found at depths of only a couple of fathoms, in the sea between Norway, Spitzbergen, and Greenland, where they occur at depths of 20–500 fathoms. Further, dead shells of shallow-water forms like *Portlandia arctica* have been dredged up from depths of 656–1333 fathoms off Spitzbergen, where they are associated with numerous otoliths of fishes. Dr. Nansen agrees with the author that these dead shells are distributed over too wide areas to be accounted for by ice-transport from the shallow-water localities round the coast, and on the supposition that they are now in the spots where they lived, it would be needful to postulate a former elevation of the sea-bottom to the extent of 800–1400 fathoms. Brögger considers that during the great glaciation the land may have been elevated perhaps to 2,600 metres above its present level, and this would furnish an explanation of the formation of the deep fjords, and of the movement of the land-ice from the Scandinavian highlands to the central European plain during the great glaciation.

The banks of dead littoral shells forming a continental platform along the west coast of Norway, at depths of 100–300 metres, are compared with the sunken shell banks of Rockall and those off the Faroe Islands, and they are considered by the author to point to a widespread elevation of the sea-bottom amounting to 100–300 metres in the last interglacial period, which may have continued during the last glaciation of Norway.

In the lower part of the valley of the Glommen, near Frederikstad, the lower Yoldia-clay is overlaid by another clay not more than 1–2 metres in thickness, containing nearly the same fauna as the lower bed, but the forms are smaller, and some new species appear, for example *Yoldia hyperborea*, Loven, which lives at greater depths than *P.* (*Yoldia*) *arctica.* These facts show that the upper Yoldia-clay was formed at greater depths than the lower, and that the sinking of the land was continuous.

The upper Yoldia-clay gradually passes upwards into another deposit, only a few metres in thickness, in which most of the species are new, whilst *Portlandia arctica*, the characteristic shell of the Yoldia-clays, has quite disappeared. Amongst the principal forms are *Arca glacialis*, Gray, and *Portlandia lenticula*, Fabr., and from the first of these the beds are named Arca-clays. They contain about twenty species of mollusca, all high Arctic forms, which now live at considerable depths in the Polar Sea, and it is probable the beds were laid down at depths of 80–100 metres. Like the Yoldia-clays, the lower Arca-clays are only found outside the ra, and as some of them are now 25–40 metres above the sea-level, it follows that the land, at the closing period of the outer ra, was 100–125 metres lower than at present.

After the deposition of the lower Arca-clays on the areas beyond the outer ra, a somewhat rapid change in the rate of melting of the glacier took place, which resulted in the retreat of the ice northwards up the Christiania fjord for a distance of 20–25 kilometres, where another pause was made which resulted in the formation of the Svelvik terminal moraine, or inner ra. In structure this resembles the outer ra: it was laid down beneath the sea; its present height is 150–190 metres above the sea-level. It has a length of about 2 kilom., and the breadth of its base is 1½ kilom. Two-thirds of its materials consist of sand; the remainder are pebbly gravels of granite, hornblende schist, and quartzite, with a few angular striated boulders.

The extensive areas between the outer and the inner ra are covered by thick deposits of clay which rest directly on the striated surfaces of the older rocks. Only a scanty fauna of about a dozen species, most of them of a high Arctic character and similar to those in the lower Arca-clays, are known from these beds, which are termed the middle Arca-clays. The principal forms are *Arca glacialis*, distinctly smaller than those in the lower beds, and *Portlandia lenticula*. These middle Arca-clays are now at levels of 150 metres above the sea; they indicate a further sinking of the land during the withdrawal of the ice from the outer to the inner ra.

From the inner ra at Svelvik the glacier melted back northwards to the valleys of Drammen, Lier, and Christiania, where the third stage in its retreat is marked by terminal moraines, similar to those lower down, most of which served to dam up lake-basins behind them. In the districts vacated by this stage of the ice retreat, Brögger has recognized a clay deposit of deep-water origin, the younger or upper Arca-clay, in the lower parts of the valley, up to about 120–130 metres above sea-level, containing thirty-seven species of mollusca, and somewhat higher, at levels up to 175 m., a clay of a somewhat shallower character, named the younger Portlandia-clay. The fauna of the younger Arca-clay is not, like that of the older Yoldia-clays, of a purely Arctic character, for only about half the species in it are now living in the Kara Sea; it contains an admixture of boreal species, and it corresponds with that now existing at depths of 100–200 m. off the north coast of Norway.

The further withdrawal of the ice northwards is marked, as hitherto, by moraines at intervals where pauses have taken place; the fourth of these occurs behind the clay terrace at Lilleströmmen, and a fifth at the south ends of the large lakes of Central Norway—Mjösen, Hurdalsvand, Randsfjord, etc. At this fifth or epiglacial station, as it is designated, enormous masses of clay, and upon these to the north, sands and gravels, are spread over the terraces of Romerike and part of Ringerike. These gravels appear to have been all laid down beneath the sea; they are now about 225 metres above sea-level. But few mollusca are found in the clays between the third and epiglacial moraines; the principal species are *Portlandia lenticula* and *Astarte compressa*, and the beds are named after the first of these.

One of the most striking phenomena of the period of the greatest submergence in the Christiania fjord is the well-known coral reef, so carefully described by M. Sars, consisting of masses of the deep-water coral *Lophohelia prolifera*, Linn., which, in a dead but well-preserved condition, occur at Dröbak, south of Christiania, covering the sea-bottom at levels of 60 metres below the surface, and they are also found over an area of about 100 square kilom. to a height of 30 m. above the sea. Associated with the coral is the giant form of *Lima excavata*, Fabr. Both the coral and shell are now found living in the Norwegian fjords at depths of 100–300 fathoms, and it is probable that they existed in the Christiania fjord at a depth of not less than 150 metres, when the climate was not very different from the present and the margin of the land-ice yet stood before Mjösen and Randsfjord.

The upper marine boundary at Christiania is about 216 metres (708 feet) above the sea-level, and the maximum of the subsidence occurred when the ice had retreated behind the epiglacial station, and this morainic dam appears to have barred the further extension inland of the sea, for behind it no marine deposits have been met with. The further melting back of the ice took place when the period of elevation had set in, and the valleys then became fresh-water lakes.

The full extent of the depression of the land at the time of the last ice-sheet is unknown; that portion of it, from the time of the outer ra to the epiglacial moraine, which can be approximately ascertained, probably represents only the smaller half of the subsidence. Shortly before the formation of the outer ra, the land was probably about the same level in relation to the sea as now; during its deposition the land sank to about 100–125 metres lower than at present, and at this period the older and newer Yoldia-clays and the lower Arca-clay were deposited. When the moraines of the inner or second ra were formed, the subsidence reached to 185 m. at Hougen, and at the third morainic station in the Christiania valley to about 200 m.; in front of these moraines the newer Arca-clay and the Portlandia-clay were laid down. At the time of the epiglacial moraines, when the subsidence ceased, the land south of Lake Mjösen had sunk about 240 m. (787 feet).

The climate of the Christiania region during the long period of subsidence changed from a high Arctic character to that of a boreal Arctic. At the time of the lower Yoldia-clay the average temperature was probably —6°– —9° C., similar to that of the Kara Sea; in the upper Yoldia-clay period, —4° C., like that of the sea round Nova Zembla; whilst at the time of the upper Arca-clay it had risen to 2° C., similar to that of West Finmark. At the close of the subsidence, during the formation of the epiglacial moraine, the climate probably differed but little from the present one.

The author proposes to designate the whole interval of the late glacial subsidence, which may well have comprised some thousands of years, the Christiania period, and he considers it to correspond with the Champlain period of North America.

II. *The Late Glacial Shell Beds and Clay Deposits formed during the Elevation of the Land.*

The very highest occurrences of late Glacial marine shells in the Christiania district were discovered by Mr. P. Öyen in littoral sands and gravels at Grefsen and Årvold, near Christiania, at levels of 203–208 metres above the sea, only a short distance below the maximum marine margin, which here is 216–218 metres. The shells belong to but few species; they include *Mytilus edulis, Macoma baltica, Mya truncata, Saxicava pholadis*, etc. The shells occur for the most part as casts or impressions; the beds are of a very different character from those at lower levels, and they may probably be referred to the concluding part of the period of subsidence rather than to that of elevation. They are overlaid by gravels with numerous large boulders.

The higher, late Glacial shell beds in the vicinity of Christiania have long been known through the descriptions given by Keilhau, M. Sars, and Kjerulf. They consist, for the most part, of sands and pebbly gravels, crowded with fragments of broken shells, and in some places entire forms, belonging to the littoral or the highest part of the laminarian zone, which lived at depths not more than about 10 metres. They are known as the Mya-beds, from *Mya truncata*, one of the most characteristic forms; *Mytilus edulis* is also common; other species are *Cyprina islandica, Macoma baltica, Littorina littorea*, etc. In the southern part of Smålenene, to the south-east of Christiania, the upper Mya-beds contain 23 species of mollusca, 17 of which are Arctic and 6 boreal forms. The beds are situated at levels of 130–155 metres above the sea. In the lower Mya-beds, near Fredrikshald in the same district, 45 species of mollusca are known; of these 22 species are Arctic, 20 boreal, and 3 Lusitanian. In the same beds near Christiania, at 110–140 m. above the sea, 26 species of mollusca are known, 9 of which are Arctic, 13 boreal, and 4 Lusitanian.

A series of fossiliferous clay-beds, corresponding with the Mya-beds of the higher or early stages of the uplift, are found in the Christiania valley, and are known as the Mytilus-Cyprina-clays. At Grorud lower and younger clays occur, containing a number of southern (Lusitanian) species, including *Pholas candida, Cardium edule*, etc.; they are known as the oldest Cardium-clays.

From differences in the character of the shell beds in various localities, at levels corresponding to the same percentage of the total uplift, it would appear that the elevation of the region began earlier in the southern peripheral portions once covered with the ice-sheet, and continued in advance of that of the central portions, at least during the first half of the uplift.

III. *The Post-Glacial Shell Beds and Clay Deposits of the Christiania Region.*

Shell beds, lower and younger than the Mya-beds, corresponding to the middle period of the uplift, that is, from 40 to 66 per cent. of the total elevation of the land, are somewhat rare, and it is therefore difficult to fix a definite boundary between the late Glacial and the post-Glacial deposits, but it is probably situated at a level of something over half (50–60 per cent.) of the total uplift.

At Bryn, near Christiania, there is a younger Cardium-clay, corresponding to the middle period of the uplift, the fauna of which has been described by Crosskey & Robertson. It contains 15 species of mollusca, only 1 of which is Arctic, whilst 7 are boreal, and 7 Lusitanian species. The beds are now 76–85 m. above the sea, and the shells probably lived at depths of 20–30 m. The highest marine shore-line here is 215 metres.

During the later stages of the uplift of the land, beds of shells and clay deposits were successively formed at lower levels; the fauna in these varies in the direction of a gradual increase of boreal and Lusitanian species and the disappearance of Arctic forms. Lists of species found at different localities are given, and the following grouping has been adopted by the author.

The uppermost, Ostrea-beds, which come next below the level of the Cardium-clay, contain 77 species of mollusca, of which $\frac{2}{11}$ are Arctic, $\frac{6}{11}$ boreal, and $\frac{3}{11}$ Lusitanian, indicating a climate nearly similar to the present. In contemporaneous clays at Jarlsberg there are remains of hazel, oak, *Rubus*, *Viola*, etc.

Next younger are the upper Tapes-beds, which are strikingly developed at Dröbak to the south of Christiania. The fauna of these beds has been carefully worked out by Sars and others. With few exceptions the species are the same as those in the Ostrea-beds. The commoner genera are *Tapes*, *Ostrea*, *Mytilus*, *Astarte*, *Cardium*, and *Littorina*. Altogether 216 species of mollusca have been recorded from these beds, of which 34 are Arctic, 89 boreal, and 93 Lusitanian, or in the proportions respectively of $\frac{1}{7}$, $\frac{3}{7}$, $\frac{3}{7}$. The species indicate a climate notably milder than at the beginning of the post-Glacial period, and probably even milder than the present. Shell beds corresponding to these Tapes-deposits are known in Sweden, along the shores of the Cattegat, in Jutland, also along the Norwegian coast, west of the Christiania fjord. At Jæderen, near Stavanger, refuse shell heaps or 'kitchen middens,' of the older Neolithic age, have been found at levels of 18 metres above the sea, showing that the flint folk lived in Norway during the Tapes-period. These beds have also been traced as far north as Vardö, where they contained 26 species of mollusca, of which 3 only are Arctic, 11 boreal, and 12 Lusitanian. A number of these last are now extinct in that region, which confirms the view as to the mildness of the climate in the Tapes-period.

Contemporaneous with the littoral Tapes-beds, there is in the Christiania valley a widespread clay deposit, probably laid down at depths of 15–40 metres, known as the Isocardia-clay, after its leading fossil, *Isocardia cor*, Linn. Eighty-two species of mollusca, mostly the same as those in the Tapes-beds, are recorded from it, together with remains of oak, fir, birch, and hazel.

Corresponding with the final stages of the post-Glacial elevation, there are a number of littoral shell beds known as the lower Tapes-beds, spread over the Christiania region at levels of 1–13 metres above the sea, and associated with them are clay-deposits, named the Scrobicularia-clays. At Barholmen, near Dröbak, these beds have yielded 124 species of mollusca, of which 18 are Arctic, 53 boreal, and 53 Lusitanian; thus showing an important immigration of southern forms during their deposition. At Brevik numerous species of foraminifera, echinoderms, entomostraca, etc., were determined from the lower Tapes-beds by Münster, whose list is quoted.

The Scrobicularia-clays are the lowest and latest post-Glacial shell beds in the Christiania region; they are now met with at levels from slightly above to slightly below the sea. The beds are often brought to light in the excavations for buildings in the lower part of the city of Christiania. The most characteristic species is *Scrobicularia piperata*, a southern form which extends to the Mediterranean. Though still living off the west coast of Norway at depths of 0–8 metres, it no longer inhabits the Christiania fjord.

The total number of species in this youngest post-Glacial deposit, including the Scrobicularia-clays, is 245, of which 34 are Arctic, 102 boreal, and 109 Lusitanian species, or approximately in the proportions of $\frac{1}{7}$, $\frac{3}{7}$, $\frac{3}{7}$. The Lusitanian or southern element has distinctly increased in these beds, both by the introduction of new species and the predominance of others.

The *living* molluscan fauna of the Christiania fjord comprises 268 species, as against 255 species in the post-Glacial fauna; 210 species are common to both. Forty-five post-Glacial species have not as yet been met with living in the Christiania fjord, whilst 53 species now living in the fjord are not known in the post-Glacial beds of the region. A significant number of the Lusitanian forms of the post-Glacial beds have disappeared from the fjord and the nearest portions of the Norwegian coast, even after the land had been elevated to its present level. Amongst those in the existing fauna and not known in the post-Glacial deposits, there are several Arctic species which apparently have migrated to Scandinavia from the northern part of the American continent, where they still live; they are unknown in the Polar Sea to the north of Asia. This shifting of species shows that the boreal element is more prominent in the present fauna of the fjord than during the latest post-Glacial time, when the climate also seems to have been 2° C. warmer than at present.

There is no conclusive evidence in the Christiania district of a depression corresponding to the *Ancylus* or *Littorina* depression of the Baltic basin. In some localities a deposit of warm, comparatively shallow-water, post-Glacial clay (Isocardia-clay as a rule) rests unconformably, with a sharply defined junction-plane, on the cold deep-water Arca-clay, from the upper surface of which boulders project to which balani and oysters are attached, indicating that this surface cannot have been elevated and exposed to atmospheric erosion before the post-Glacial clay was laid down over it. Some of the recorded occurrences of clays of deep-water origin intervening between shallow-water shelly sands may have originated by the sliding down of clay-beds from higher levels of valley slopes, instances of which are not uncommon.

At the end of the book a table is given showing the changes of level, the variations in the molluscan fauna, and in the climate of the Christiania region from the Yoldia-clay of the ra period to the present, and this is followed by a list of species of all the known shell-bearing mollusca in the late Glacial and post-Glacial deposits, showing their distribution in the different periods.

In concluding this notice we desire to call attention to the admirable way in which the mollusca, so fully treated in the work, have been illustrated. To awaken the interest of the student and stimulate fresh observations, the author has given in the nineteen plates, and partly also in the text, figures of all the species of mollusca hitherto known from the late Glacial and post-Glacial deposits of the Christiania region, and these have been excellently and faithfully drawn by Froken Sigfrid Bergh, the artist to the University of Christiania. The geologists of this country and elsewhere, to whom Norse is an unknown tongue, will also much appreciate the full summary in English of the contents of the work, extending over 35 pages, which the author has prepared. G. J. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—April 30th, 1902.—Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair.

Mr. J. E. Marr exhibited some specimens from a metamorphosed metalliferous vein several inches wide, which he had discovered in the basic andesites near the Shap Granite, in a quarry close to the high road, north of the spot where it crosses Longfell Gill.

The minerals of the vein include quartz, calcite, garnet, epidote, hornblende, galena, iron-pyrites, and copper-pyrites. Some of the garnets are about an inch in diameter. The epidote and the hornblende tend to form distinct bands on the margin of the vein. The other metamorphic phenomena recall those described by the exhibitor and Mr. Alfred Harker, in the case of large vesicles occurring in the same rocks.

The specimens are of interest as showing :—

(i) The existence of metalliferous veins in Ordovician rocks which have been formed in pre-Carboniferous times, for the Shap Granite which has produced the alteration is itself pre-Carboniferous.

(ii) The alteration of a metalliferous vein of complex composition by pyrometamorphism, an occurrence which the exhibitor believed had not previously been recorded.

(iii) The possibility that some of the highly crystalline rocks of a complex of regionally metamorphosed rocks may owe their characters to hydrothermal action having formed veins along the parallel divisional planes of pre-existing rocks, these veins having been subsequently altered by pyrometamorphism.

The following communications were read :—

1. "The Origin and Associations of the Jaspers of South-Eastern Anglesey." By Edward Greenly, Esq., F.G.S.

Red jasper and jaspery phyllite are widely distributed in the southern and south-eastern parts of Anglesey, in the districts of Newborough, Pentraeth, and Beaumaris. They are associated with limestones, diabases, serpentines, and with grits and shales. They have been much modified by earth-movements, which have produced brecciated and schistose structures; but where original structures have survived, the true relations of the rocks can often be seen. The diabases have the same characters as the pillowy and variolitic rocks so often associated with radiolarian cherts and jaspers in many parts of the world, and at several different geological horizons; and the relationships of the jaspers and igneous rocks resemble those seen in the radiolarian cherts of Southern Scotland. It is inferred that the jaspers are altered radiolarian cherts. The evidence for the age of the group is incomplete. There is not sufficient evidence to refer it to the Arenig Series, and it is possible that it belongs to an altogether different period. Its relation to the crystalline schists of the region is obscured by conflicting evidence: one chain of reasoning leads to the view that the group is older than the schists, and has been involved in their metamorphism; while another gives strong reason for supposing that it is of later date.

2. "The Mineralogical Constitution of the Finer Material of the Bunter Pebble-Bed in the West of England." By Herbert Henry Thomas, Esq., B.A., F.G.S.

Specimens were collected at intervals, from Budleigh Salterton, in Devon, to Fitzhead near Milverton, in Somerset, and other sands, for comparison, were taken from the red rocks above and below. After treatment with acids, to remove iron-oxides, the sands were separated by heavy liquids into three parts:—

(*a*) Heavy residue: specific gravity exceeding 2·8.
(*b*) The bulk of the quartz.
(*c*) The lighter part, with most of the alkali-felspar.

The sands, on the whole, contain a very small percentage of minerals with a specific gravity of more than 2·8; while the proportion of material over, to that under, 2·58 is about 70 or 80 to 30 or 20 per cent. A list and description of twenty minerals found in the sands is given, with, in some instances, the chief characters by which they were identified. The compound grains include felsite, quartzite, chert, shimmer-aggregates, leucoxene, and other decomposition-products. The gradual decrease in the percentage of heavy minerals from Budleigh Salterton to Uffculm indicates the carriage of sediment by a southerly current, and this view is strengthened by the decrease in staurolite and a gradual diminution in the size of the tourmaline-grains. The increase in proportion of heavy grains from Uffculm to Milverton, and the further decline northward, together with the incoming of an assemblage of minerals markedly different from the normal southerly type, indicates an additional source of supply, perhaps a westerly current. The mass of material seems to have been furnished by a highly metamorphosed area, differing widely in its character from any now exposed in the south-west of England. The most probable source of much of the material is the Armorican massif of Triassic times.

3. "Revision of the Phyllocarida from the Chemung and Waverly Groups of Pennsylvania." By Professor Charles Emerson Beecher, Ph.D., F.C.G.S.

The specimens described in the paper, as well as those on which the original descriptions were based, were all obtained in the vicinity of Warren, Philadelphia. The chief horizon is in the shale-beds of the Upper Chemung Group, about 50 feet above mean water-level in the Allegheny River. The deposits are called by the writer the 'Phyllocarid Beds.' Additions and emendations to the original diagnoses of the following genera and species are given: *Echinocaris socialis*, Beecher; *Tropidocaris, Tr. bicarinata*, Beecher, *Tr. alternata*, Beecher; *Elymocaris, E. siliqua*, Beecher; and two new species of *Echinocaris* are described.

II.—May 14th, 1902.—Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair.

The President referred in feeling terms to the recent calamitous occurrences in the West Indies, and to the geological interest of the phenomena. The Council had been considering in what way they could best give expression to the sympathy of the Fellows, both with our own Colonies and with their French neighbours, and had requested Sir Archibald Geikie and himself to act as they thought best in the matter.

Professor Boyd Dawkins moved that the Fellows express their sympathy with the sufferers in the two islands, and approve the action taken by the Council.

Mr. H. W. Monckton seconded the motion, which was carried.

The following communications were read:—

1. "On Pliocene Glacio-Fluviatile Conglomerates in Subalpine France and Switzerland." By Charles S. Du Riche Preller, M.A., Ph.D., A.M.I.C.E., M.I.E.E., F.G.S.

In a paper read before the Society in 1896 the author described a variety of Deckenschotter deposits above, near, and below Zurich, which, occurring both on the hills and at low levels of the valleys of that district, tended to the conclusion that at the time of their formation, towards the end of the Pliocene Period, the principal valleys and lake-basins of Subalpine Switzerland were already eroded approximately to their present depth.

Further examination has, however, led him to recognize that the low-level deposits, although in many respects not unlike Deckenschotter, are the products of the younger or Pleistocene glaciation, and that only the deposits *in sitû* on the ridge of the hills can be referred to the Pliocene glaciation of the Alps.

In the present paper the author describes a number of further deposits of typical Deckenschotter conglomerate recently examined in the Aare and Rhine valleys, near the confluence of those rivers, and shows that these, in conjunction with the Deckenschotter deposits of the Zurich district, indicate the almost unbroken outline of a Subalpine Deckenschotter cone, which extended from the base of the Alps in a north-westerly direction over a distance of about 25 miles, and was formed by the waters of the retreating Rhine (Western) glacier and its affluents on a molasse plateau, the upper and lower ends of which were at the contours of 900 metres and 500 metres respectively.

He further describes a series of Deckenschotter deposits examined in the Rhone Valley between Lausanne and Lyons, including the extensive plateau of the Dombes, east and north of Lyons, composed of marine marl overlain by the characteristic conglomérat ferrugineux, which some French geologists still regard as pre-Glacial and others as Quaternary, but which is typical Deckenschotter, and in the full acceptation of the term an alluvion des plateaux. The deposits thus described afford proof of the existence, in Upper Pliocene times, of an extensive alluvial cone about 100 miles in length, which reached from Lausanne (probably even from the base of the Alps) to Lyons, and was formed by the waters of the retreating Rhone and Arve glaciers on a Molasse-and-marl plateau, the altitude of which above sea-level was 800 metres near Lausanne and 300 metres near Lyons.

From this concurrent evidence in Northern Switzerland and in the Rhone Valley, the author is led to conclude—

(1) That at the time of the deposition of those alluvial cones, the principal Subalpine valleys and lake-basins could not as yet have existed in their present form or depth, and must have been from 100 to 200 and 400 metres higher; and

(2) That the Subalpine valleys were eroded to their present depth in the course of the inter-Glacial Period—now recognized to have been of very long duration—between the Pliocene and the Middle Pleistocene (or maximum) glaciations, and that the Subalpine lake-basins were formed in the same period by the contemporaneous action of fluviatile erosion and of a zonal settling along the base of the Alps after these had been raised by horizontal pressure.

2. "Overthrusts and other Disturbances in the Braysdown Colliery (Somerset), and the Bearing of these Phenomena upon the Effects of Overthrust Faults in the Somerset Coalfield in general." By Frederick Anthony Steart, Esq. (Communicated by Horace B. Woodward, Esq., F.R.S., F.G.S.)

This coalfield, although covered by comparatively undisturbed Secondary rocks, is in part the most disturbed and contorted of those known and worked in the United Kingdom. It is seldom, in some parts of it, that one sees 200 yards of coal without a fault or other disturbance. The 'Radstock Seams' of the Upper Coal-measures at Radstock are traversed by a huge 'overlap fault,' which thrusts them forward for a great distance; this runs nearly east and west, and has parallel to it two smaller overthrusts. In one of them the coal at first dips towards the thrust, then it thickens from 2 to 6 or 8 feet, next it becomes inverted, and eventually regains its former character. The continuity of the coal has been proved in the case of three of the coal-veins. As there is practically the same sequence of strata on both sides of the fault, it is concluded that the 'overthrusts' did not take place till all the coal-seams of the Radstock Series had been deposited. The areas of 'dead ground,' sometimes considered to be wash-outs, are probably also the result of movement. The areas occur near faults, frequently take a course parallel to overthrust faults, and at their margins the coals are often reduplicated. 'Dead ground' is usually found only in those seams which lie on a floor of soft black shale, and sometimes, instead of dead ground, there are large areas with very thin coal. The flat roofs of coal-seams in the dead ground are invariably striated. The author's theory is that all these effects have been caused by the gradually increasing movement of the strata from the top seam or 'Great Vein' to the bottom seam or 'Bull Vein.' The coal-seams nearly always thin from their undersides upward, as though the floor had moved farther, or at a greater rate, than the roof.

III.—May 28th, 1902.—Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair.

The President reported that in consonance with the resolution passed at the previous meeting of the Fellows, he and Sir Archibald Geikie had forwarded a letter to the French Minister of the Colonies and H.M. Secretary of State for the Colonies, expressive of the sympathy of the Geological Society with the sufferers from the volcanic catastrophes in Martinique and St. Vincent.

The Secretary read the following letter regarding the recent fall of volcanic ash in Barbados, and reported that the thanks of the Council had been conveyed to the writer :—

"Imperial Agricultural Department for the West Indies, Barbados.
9th May, 1902.

"DEAR SIR,—I am sending you by this mail a small quantity of the volcanic ash that fell at Barbados soon after the volcanic eruption at St. Vincent on Wednesday last. I am also sending you newspaper reports, and you will obtain practically all particulars from them. There is a note about the ash in the *Agricultural News*, giving an estimate of the quantity per acre that fell in this island. It is singular that the circumstances correspond so exactly with what took place in 1812. Fortunately, within four hours after the fall of the ashes, we have had drenching showers which have, to a great extent, washed the ashes from the roofs of the dwellings and from vegetation, and also laid the dust which during yesterday was most trying and uncomfortable. The roads are still covered with a sandy coating, which is not at all muddy or sticky. Naturally the chemical composition of the ash is of great interest to the planters, as it may have an appreciable effect on next year's crops. The old canes have nearly all been reaped, and the young canes are in such a condition that they should largely benefit by any fertilizing properties that may be in the ash. In the case of the ash that fell in 1812, Davy is said to have found it to contain silex, alumina, oxide of iron, and oxide of manganese. I noticed that the ash at first was rather coarse and of a brownish colour, then it became slightly redder, while the final deposits consisted of a whitish-grey, impalpable powder. I shall send you any further particulars that may come to hand.—With kind wishes, believe me,

"Sincerely yours,
(Signed) D. MORRIS.

"The SECRETARY, Geological Society,
Burlington House, Piccadilly, London."

Professor W. Boyd Dawkins exhibited a series of photographs and specimens of sand-worn pebbles collected by Lady Constance Knox in New Zealand. The district in which the specimens occur is near the coast of North Island, in the neighbourhood of the River Waitotara, from a tableland about 250 feet above sea-level.

"On the tableland, above high cliffs, are rolling sand-dunes, which are continually shifting with every storm, and extend for several miles along the coast; among them are to be found interesting kitchen-middens. Directly inland from the sand-dunes is the district covered with sand-worn stones, extending over an area of some miles.

At first these stones are few and scattered, but they are found to increase in number as one approaches the Waitotara River. Projecting from the surface are masses of stratified rock, composed of shell-conglomerate: these also have been worn by the wind."

The following communications were read :—

1. "The Red Sandstone Rocks of Peel (Isle of Man)." By William Boyd Dawkins, M.A., D.Sc., F.R.S., F.G.S., Professor of Geology in Owens College (Victoria University), Manchester.

The Red Sandstone Series, ranging along the coast from Peel to Will's Strand, is faulted into the Ordovician massif of the Isle of Man. It has been referred to the Old Red Sandstone, the Calciferous Sandstone, the basement Carboniferous, and to the Permian. The series consists of red sandstones containing irregular conglomerates and breccias, more or less chemically altered, known in the Lake District as 'Brockram.' Sections at Ballagnane, Creg Malin, and at the Gob and Traie Fogog are described in detail; the rocks are classified, and their range to the north-east and inland is described. It is pointed out that the rocks are different in many respects from the basement Carboniferous rocks of Langness and elsewhere, and a list of the materials contained in the 'Brockrams' is given. All these materials have been derived from rocks similar to those which form the Lower Carboniferous Series in the Lake District, with the exception of one or two types which might belong to any other pebble beach. The fossiliferous pebbles in the rocks in question are described, and their fossil contents determined. The whole group of fossils is Lower Carboniferous and Ordivician, and centres mainly in the Carboniferous Limestone. A comparison is instituted with the Permian rocks of Barrowmouth, the Vale of Eden, and elsewhere. The rocks are much sheared and faulted; the planes of shearing intersect the bedding-planes, and divide the rock into lenticular and diamond-shaped masses, which are scored and slickensided. The earth-movement to which this is due took place in the interval between the latest Palæozoic and earliest Mesozoic deposits. The iron in the rocks was probably derived from the destruction of the Carboniferous shales.

2. "The Carboniferous, Permian, and Triassic Rocks under the Glacial Drift in the North of the Isle of Man." By William Boyd Dawkins, M.A., D.Sc., F.R.S., F.G.S., Professor of Geology in Owens College (Victoria University), Manchester.

The whole of the Isle of Man, north of a line drawn due west from Ramsey, is covered with a thick mantle of Glacial Drift. South of this line rises the ice-worn Ordovician massif. Six borings carried out under the advice of the author have elucidated the geological structure of the Drift-covered area. The borings at Lhen Moar, Ballawhane, Knock-e-Doony, Ballaghenny, and two at the Point of Ayre are described in detail, and the rocks classified. The first shows Carboniferous Limestone under Drift; the second and third, Trias, Permian, Yoredale, and Carboniferous Limestone; the fourth, Trias, Permian (thin), and Yoredale; the fifth and sixth, Trias, with gypsum and 76 feet of rock-salt. The rocks all dip in natural order towards the north, and constitute a plateau of marine erosion sloping to the north and east, covered with Drift, which is in places not less than 450 feet thick.

3. "Note on a Preliminary Examination of the Ash that fell on Barbados, after the Eruption at St. Vincent (West Indies)." By John Smith Flett, M.A., D.Sc., F.R.S.E., F.G.S. With an Analysis of the Dust by William Pollard, M.A., D.Sc., F.G.S.

Two samples of the material were sent by Dr. D. Morris, of the Imperial Agricultural Department for the West Indies, to Professor J. W. Judd, who forwarded them to the Director of the Museum of Practical Geology. The fine grey powder is gritty to the touch, and it all passed through a sieve with 30 meshes to the inch. It contains plagioclase-felspar (generally idiomorphic labradorite) coated with a thin film of glass, hypersthene and monoclinic brownish augite, both frequently in perfect crystals, magnetite, apatite, possibly zircon, and fragments of a brown glass. Among the finest débris there is much felspar in the form of minute chips. The perfect crystalline form of many of the constituents of the dust and the small amount of glass adherent to them, indicate that at the time of projection the glassy magma must have been very fluid, and it must have been to a large extent wiped off the crystals by friction. From Dr. Morris's account the minerals of high specific gravity appear to have fallen first; the order being magnetite and pyroxenes first, next the felspars, and finally the glass threads and minute felspar débris. Dr. Pollard's analysis is as follows:—$Si\,O_2 = 52{\cdot}81$, $Ti\,O_2 = {\cdot}95$, $Al_2\,O_3 = 18{\cdot}79$, $Fe_2\,O_3 = 3{\cdot}28$, $Fe\,O = 4{\cdot}58$, $Mn\,O = {\cdot}28$, $(Co\,Ni)\,O = {\cdot}07$, $Ca\,O = 9{\cdot}58$, $Mg\,O = 5{\cdot}19$, $K_2\,O = {\cdot}60$, $Na_2\,O = 3{\cdot}23$, $P_2\,O_3 = {\cdot}15$, $S\,O_3 = {\cdot}33$, $Cl = {\cdot}14$, $H_2\,O = {\cdot}37$; total 100·35.

CORRESPONDENCE.

FIGURES OF *CAMPYLOPRION*, PLATE VIII.

Sir,—Owing to my not having had the opportunity to see proofs of illustrations for my article on *Campyloprion* in the April number of the Magazine, a slight error occurred in designating their scale of reduction. Figs. 1 and 2 of Plate VIII are reduced to about three-sevenths natural size, and Fig. 3 in the text is of the natural size. In the Explanation of Figures on p. 152, the fused teeth of *Campyloprion* are stated to be "supported at their bases by a band of calcified cartilage." This should be understood as an inference drawn from analogy, and not as implying that the basal parts of the segments in this genus or in *Edestus* are of calcified cartilage, when they have been well ascertained to consist of vasodentine. C. R. Eastman.

Museum of Comparative Zoology,
Cambridge, Mass.

VON ZITTEL'S HISTORY OF GEOLOGY.

SIR,—I am one of those who in consequence of your notice in the April number at once sent for the translation of Von Zittel's History of Geology, etc. I read it with avidity, and can endorse all that was said about the book. Specially was I interested in the masterly manner in which the subject of metamorphism, the discussion on the Cambrian and Silurian systems, the *Eozoon Canadense,* the North-West Highlands of Scotland, and the unravelling of the Alpine strata were treated, with the various points still open for investigation.

There are, however, on p. 159, which contains statements as to the diameter of the planets, and on p. 168, where the thickness of the solid crust of the earth is dealt with, also on p. 300, where the shortening of the earth's radius is mentioned, figures given which I do not understand. The writer or the translator must have had some modulus of dimension in mind different from any of those stated in the text. It would be well before a second edition is produced that these points should be reconsidered.

The following are the clauses remarked upon :—

Page 159 : "Of the six planets that were known in early astrology, Mercury is nearest the sun in position, and has itself a diameter of 648 miles; Venus (diam. 1,613 miles) follows Mercury, then the Earth (diam. 1,719 miles), then Mars (diam. 909 miles), Jupiter (diam. 19,000 miles), and Saturn (diam. 16,675 miles). Herschel in 1780 discovered on the farther side of Saturn the planet Uranus with a diameter of about 8,000 miles, and Leverrier in 1846 discovered by mathematical calculation the outermost planet, Neptune, with four and a half times the diameter of the Earth."

The ordinary textbooks give—Mercury, 2,000 miles diameter; Venus, 7,600; Earth, 7,928; Mars, 4,430; Jupiter, 86,000; Saturn, 76,246; Uranus, 32,000; Neptune, 35,000.

Page 168 : "Hopkins calculated that the solid crust of the earth had a thickness of about $\frac{1}{4}$ or $\frac{1}{5}$ of the earth's diameter, that is, at least 172 to 215 geographical miles."

Page 300 : "Delesse had calculated 1,340 metres as the amount by which the earth's radius had already been shortened; in other words, the earth's crust in the course of the geological epochs had approached the earth's centre by a distance about equal to the height of Chimborazo or the Himalayas above sea-level."

THOMAS M. RICKMAN.

8, MONTAGUE STREET, RUSSELL SQUARE, W.C.
May 31, 1902.

THE LIMITS OF LEGITIMATE SPECULATION AT THE GEOLOGICAL SOCIETY.

SIR,—Early in 1900 I submitted to the Geological Society a short paper on Bala Lake and the rivers of North Wales, in which I attempted to show that the great valleys which run through North Wales from north-east to south-west had probably been formed by earth-movements, and had produced a great effect upon the river-system. In the discussion which followed this view was severely criticized by Mr. Strahan, and was characterized by him as highly speculative.

A few months ago Mr. Strahan read at the Geological Society a paper on the rivers of South Wales; and in this he makes the suggestion, quite as if it were new, that the north-east to south-west valleys are due to earth-movements, and that the complications of the drainage system have been produced by these movements.

My paper was rejected by the Council[1] as too speculative: Mr. Strahan's has just been published in the Quarterly Journal.

To those Fellows who are not familiar with Burlington House, I commend a comparison of these two papers.

PHILIP LAKE.

MR. STRAHAN AND SOME ENGLISH RIVERS.

SIR,—In his suggestive paper "On the Origin of the River System of South Wales, etc.," in the recently published May number of the Quart. Journ. Geol. Soc., Mr. Strahan states (pp. 219–220) that "The [Chalk-] escarpment, in that part of it which extends from Dorset to the borders of Hertfordshire, diverges from the water-parting three times, namely, in the Vales of Wardour and Pewsey and in the valley of the Upper Thames. In *all* these cases, rivers rising in the low-lying Oolitic region flow eastward against the general run of the country, and make their way through the Chalk-escarpment to the Thames or Frome. The explanation did not escape Ramsay. *Their courses were initiated upon an eastward slope of Chalk, and the distance from their sources to the existing escarpment is a measure of the recession of the escarpment since the initiation.*"

With respect to this passage (in which the italics are mine) I should like to point out (1) that the river running eastward through the Vale of Pewsey does not rise "in the low-lying Oolitic region," but in a tract of Chalk and Upper Greensand to the east of and some 200 feet above it. (2) That inasmuch as the rivers traversing the Vales of Wardour and Pewsey follow the axes of minor east-west anticlinal folds, they are to be regarded rather as longitudinal, autogenetic branches of the north-south Salisbury Avon, than as primary, or consequent, eastward streams of the Upper Thames class. Unlike the Upper Thames, the Kennet–Thames, or the Frome, which follow the slopes of constructional troughs, these streams (i.e. the Nadder and Upper Avon) can only have come into existence after prolonged denudation of the folds on which they are situated. It is, therefore, scarcely probable that their present sources were determined by, or, indeed, are in any

[1] I owe it to the GEOLOGICAL MAGAZINE that the article subsequently saw the light (May and June, 1900).

way connected with, the former position of the main, north-east to south-west escarpment of the Chalk.

It must be admitted that in dealing with the origin of the Southern English rivers Mr. Strahan shows generally a fine disregard for the principles of drainage development. H. C. OSBORNE WHITE.

WARGRAVE, BERKS.
May 21, 1902.

OBITUARY.

WILLIAM HENRY PENNING, F.G.S.

BORN MARCH 9, 1838. DIED APRIL 20, 1902.

MR. PENNING, who joined the Geological Survey in 1867, had in previous years qualified as an engineer under the late C. H. Gregory. During his official service he was engaged in the survey of portions of Essex, Hertfordshire, Suffolk, Cambridgeshire, and Lincolnshire, and he was joint author with Mr. Whitaker and others of "The Geology of the North-Western Part of Essex, etc." (1878), and with Mr. Jukes-Browne of "The Geology of the Neighbourhood of Cambridge" (1881). He also contributed to "The Geology of the Country around Lincoln" (1888), by Mr. Ussher and others, the memoir being published after he had retired from the Geological Survey in 1882 through ill-health. On this account he spent some time in South Africa, and, regaining health, he was enabled to communicate to the Geological Society of London papers on the high-level coalfields of South Africa, on the goldfields of Lydenburg and De Kaap, and on the geology of the Southern Transvaal. A previous communication by him dealt with the physical geology of East Anglia during the Glacial Period. Mr. Penning was author of a "Text-Book of Field Geology" (1876, second edition 1879) and of "Engineering Geology" (1880).

JOHN CLAVELL MANSEL-PLEYDELL, F.L.S., F.G.S.

BORN 1817. DIED MAY 3, 1902.

IN the death of Mr. Mansel-Pleydell, of Whatcombe, Dorset, geological science has lost an energetic and enthusiastic worker, one who in the widest sense was a naturalist, for he was intimately acquainted with the plants, the mollusca, and the birds of his native county, and had published separate volumes on these subjects. The antiquities of Dorset had likewise engaged his attention, while as a Magistrate, as a member of the County Council, and as High Sheriff (in 1875) he had rendered distinguished local services. He was educated at St. John's College, Cambridge, and on the death of his father in 1863 he succeeded to the family estates, which included land in the Isle of Purbeck. Here he had fine opportunities for geological research, and the Kimeridge Clay in particular yielded to him many saurian remains, some of which were described by Owen and J. W. Hulke. In 1873 he contributed to the GEOLOGICAL

MAGAZINE a "Brief Memoir on the Geology of Dorset." Two years later he was the chief founder, and afterwards President, of the Dorset Natural History and Antiquarian Field Club, to the Proceedings of which from 1877 onwards he contributed numerous papers. In one of these he called attention to the interesting discovery of remains of *Elephas meridionalis* at Dewlish. Although he had reached the ripe age of 84 his keen interest in science was maintained to the end, and his loss will be long and widely deplored in the county and elsewhere by all who had the privilege of his acquaintance.

Mr. Mansel-Pleydell may be regarded as almost the last of the race of country gentlemen of high social position who took any deep interest in geology. For, although he was strongly imbued with a love of natural history generally, and, in fact, was what we might call 'an all-round man,' yet he always held geology in especial favour. We perceive this in the originating of the Dorset Field Club, which was founded by three Fellows of the Geological Society, viz., himself, Professor Buckman, and the Rev. H. H. Wood, rector of Holwell. While Buckman was elected secretary and Wood treasurer, Mansel-Pleydell was made president, and continued to occupy that position until his death. During the twenty-seven years of its existence the President's high reputation and his continuous work added largely to the usefulness of the Field Club, and his influence has helped to preserve it from becoming a mere archæological society—a fate which is likely to befall so many of these county associations in the near future. The Dorset County Museum likewise has been greatly indebted to Mr. Mansel-Pleydell, for during a long course of years he has enriched almost every department, and more especially that of palæontology. It is here that his most important 'finds' have been deposited.

We must regard it as a matter for regret that Mr. Mansel-Pleydell's efforts in the cause of geological science were not more generally known, so that probably few persons unconnected with Dorset have any idea of the range of his knowledge in this direction. To this circumstance we may attribute the fact that he never obtained from the Council of the Geological Society any recognition of his services in the cause of geology, although it had no more enthusiastic devotee than the late President of the Dorset Field Club. He was one of those extraordinary men who unite the enthusiasm of youth with the mature judgment of old age, and it may be recorded of him that he 'died in harness' in his effort to attend the meeting at Dorchester, where it had been his intention to deliver his annual address.

THE HUGH MILLER CENTENARY.—We draw the attention of our readers to the very interesting proposal (see p. 4 of Cover) to keep alive, by means of a Memorial Institute in Cromarty, the memory of one of Scotland's most worthy sons and geologists.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. IX.

No. VIII.—AUGUST, 1902.

ORIGINAL ARTICLES.

I. — Woodwardian Museum Notes: Salter's Undescribed Species. IX.[1]

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

(PLATE XVIII.)

Monticulipora (Monotrypa) poculum, Salter. (Pl. XVIII, Figs. 1–3.)

1873. *Monticulipora poculum*, Salter MS.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 109 (*a* 314).
1891. *Monticulipora* (?) *poculum*, Woods: Cat. Type Foss. Woodw. Mus., p. 25.

There are eight specimens (*a* 314) to which Salter gave this name. All are from the Wenlock Limestone of Dudley, and belong to the Fletcher Collection. Only one shows any part of the upper surface.

Diagnosis.—Corallum circular, broadly cup-shaped or crateriform, sharp-edged, thin. Cup shallow, concave. Base convex, broadly conical, attached by apex, covered by thick concentrically wrinkled epitheca marked with fine radiating striæ, and in some cases furnished with a few short root-like processes on the sides. Corallites radiating from centre of base, regular, hexagonal or polygonal, of equal or subequal size, thin-walled, crossed by a few horizontal or oblique tabulæ. Minute, thick-walled tubuli ('spiniform corallites') present, usually one at each angle of junction of adjacent polygonal corallites.

Measurements.

	I	II	III	IV
	mm.	mm.	mm.	mm.
Diameter of corallum	30	27	16	15
Height of ditto	8	10	7	6

Remarks.—The peculiar shape of the corallum, the thick striated epitheca, and short corallites separate this species from *M. discoidea*,[2] James, to which it has several points of resemblance, i.e., the thin-walled subequal corallites, the epithecal cover, the spiniform corallites, and the absence of monticules. The 'spiniform corallites' are not quite so abundant in Salter's species as in *M. discoidea*, and

[1] For previous articles see Geol. Mag., 1901, pp. 5, 106, 246, 355, and 576; 1902, pp. 122, 145, and 256.

[2] Nicholson: Struct. and affin. genus *Monticulipora*, 1881, p. 193, and references.

the other corallites are relatively larger than Nicholson's figure (op. cit., pl. iv, fig. 3*c*) indicates.

TRACHYPORA (?) SEELEYI, Salter. (Pl. XVIII, Figs. 4, 5.)

1873. *Alveolites Seeleyi*, Salter MS.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 107 (*a* 365).
1891. *Alveolites Seeleyi*, Woods: Cat. Type Foss. Woodw. Mus., p. 13.

The original specimen (*a* 365) consists of a fine branching corallum from the Wenlock Limestone of Dudley (Fletcher Collection), and is in an excellent state of preservation.

DIAGNOSIS.—Corallum ramose, subdividing into many small irregularly dichotomous, cylindrical, or flattened lobate branches, averaging 4 mm. in diameter, irregularly anastomosing, and covered with closely set small corallites in irregularly oblique or vertical rows, but mostly without any definite arrangement. Corallites subcircular or polygonal, subequal in size, and usually numbering 5–6 across the width of a branch 4 mm. in diameter. Corallites run obliquely outwards from axis, but meet outer surface at right angles. Cell-walls thick, strongly granulated and punctated on surface of corallum, measuring from $\frac{1}{4}$ to $\frac{1}{2}$ the diameter of the calices. Calices cup-shaped and circular owing to thickening of cell-walls, with small circular hole at bottom as in *Striatopora*. Walls of corallites thickly set with minute mural pores. Tabulæ present?

REMARKS.—It is somewhat difficult to assign this species to its proper generic position. The calices in their characters remind us of *Striatopora*,[1] the thickened cell-walls and closely set corallites of *Cladopora* (Hall & Rominger),[2] but the granulation of the walls on the surface between the calices is a characteristic feature of *Trachypora*.[3] In this genus *Trachypora* (*Dendropora*, according to Rominger, op. cit., includes it) the calices are usually much further apart, but it is doubtful if this is more than a specific character. The peculiar cup-shaped orifice is not limited to *Striatopora*, and the radiating striæ which are present within it in that genus are here wanting. It is quite distinct from *Alveolites*. No species of *Trachypora* has hitherto been definitely found in Wenlock beds, but Nicholson (op. cit., p. 106) declared that he possessed a specimen from this horizon indistinguishable from *Dendropora*.

INCERTÆ SEDIS.

PASCEOLUS (?) HOSPITALIS (Salter). (Pl. XVIII, Figs. 6, 7.)

1873. *Sphærospongia hospitalis*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 40.
1878. *Sphærospongia hospitalis*, Nicholson & Etheridge: Mon. Girvan Silur. Foss., fasc. i, pp. 10–18 (mentioned as allied to *Nidulites* and *Pasceolus*).
1884. *Sphærospongia hospitalis*, G. J. Hinde: Q.J.G.S., vol. xl, p. 835 (mentioned as probably related to *Pasceolus*).

[1] Hall: Pal. N.Y., vol. ii (1852), p. 156. Rominger: Geol. Surv. Michigan, vol. iii, pt. 2 (1876), p. 58. Nicholson: Tabulate Corals (1879), p. 97.
[2] Hall: op. cit., p. 137. Rominger: op. cit., p. 46. Nicholson: op. cit., p. 79.
[3] Rominger: op. cit., p. 61 [*Dendropora*]. Nicholson: op. cit., p. 102. Frech: Leth. Geog., Th. i, Bd. 1 (1897), p. 437.

1888. *Sphærospongia hospitalis*, G. J. Hinde: Mon. Brit. Foss. Sponges (Palæont. Soc.), p. 182.
1888. *Sphærospongia hospitalis*, Etheridge: Cat. Brit. Foss., pt. i, p. 3.
1891. *Sphærospongia hospitalis*, Woods: Cat. Type Foss. Woodw. Mus., p. 2.
1880–97. *Sphærospongia hospitalis*, Roemer (Frech): Leth. Geog., Th. i, Bd. 1, p. 296.

The original specimen, which came from the Middle Bala of the Onny River, is unfortunately missing, as Mr. Woods (op. cit. supra) mentions. But we possess four other specimens in the Woodwardian Museum from the same locality and horizon, two of which date back to Salter's time. Two of these specimens are external casts of the surface, and the other two show the surface itself, one being a nearly complete individual.

Diagnosis.—Body globular or ovoid; base or stalk unknown. Surface composed of numerous closely fitting, convex, hexagonal plates, about 1·5 mm. in diameter. Each plate has its individual convexity, and is ornamented with small irregular radiating ridges, particularly distinct near the edges of the plates. The centre of many of the plates is seen to be marked by a small tubercle, but it is generally very indistinct. No different plates nor openings visible, but indications of closely placed radiating pillars inside the body.

Measurements.—Diameters of ovoid figured specimen, 30 mm. and 25 mm.; five plates in a space of 8 mm.

Remarks.—The affinities of this species have been briefly mentioned by Nicholson, Etheridge, and Hinde in the references above given. The probable relations to *Pasceolus* are generally recognized in the shape, character of surface, and ornamentation of the plates; but some doubts must remain as to the true generic position of this species until we are better acquainted with its internal structure. Hinde (op. cit.) has declared that it cannot be left in the genus *Sphærospongia*, of which *Sph. tessellata* (Phill.) is the type.

Graptotheca catenulata, Salter. (Pl. XVIII, Fig. 8.)

1873. *Graptotheca catenulata*, n.sp., Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 171 (*a* 986).
1891. *Graptotheca catenulata*, Woods: Cat. Type Foss. Woodw. Mus., p. 120.

There is only Salter's original specimen (*a* 986) of this curious fossil, which he attributed to the Pteropoda, giving the new generic name of *Graptotheca*. This genus is not mentioned by Zittel or in any subsequent palæontological work, so far as I am aware. It is difficult to see why Salter assigned it to such a zoological position, as it exhibits no peculiarly pteropodal characters. The specimen is from the Lower Ludlow of Leintwardine, and is of an elongated subtriangular form, acutely pointed at one end, the two adjacent sides making an angle of about 30°. The other end is broad, but its true shape cannot be made out owing to the poor state of preservation. The surface is marked with 8 or 9 strong raised lines parallel to the second longest side; of these the first 4 or 5 nearest the margin are equidistant, but the others are less regular and slightly curved. Some of the lines bifurcate near the broader end. The upper edge appears to be curved over. The total length of the specimen is about 70 mm., and the width at the broader end about 35 mm. It appears possible that it may be really the crushed ventral shield of a *Scaphaspis* (*Cyathaspis*). The ornamentation is somewhat similar, and an obliquely crushed specimen of *Scaphaspis ludensis*[1] which occurs on the same horizon and at the same locality would present a somewhat similar appearance. But it is even very doubtful to what group we should properly assign this ill-defined and unsatisfactory fossil.

Favospongia Goughi, Salter.

1854. Undetermined fossil, McCoy: Brit. Pal. Foss., pl. i D, figs. 9, 9*a*.
1873. *Pasceolus Goughi*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 175 (*b* 53, *b* 54: reference to McCoy's figures).
1878. Sponge (?): Cat. Camb. Sil. Foss. Mus. Pract. Geol., p. 128.
1887. *Favospongia Ruthveni* (Salter MS.), G. J. Hinde: Brit. Foss. Sponges (Palæont. Soc.), pt. ii, p. 179.
1888. *Favospongia Ruthveni*, Etheridge: Cat. Brit. Foss., pt. i, p. 2.
1888. *Pasceolus Goughi*, Etheridge: ibid., p. 2.
1888. *Pasceolus Goughi*: Mem. Geol. Surv. Geology of Kendal, etc., 2nd ed., Table ii, p. 60 (specimens in Kendal and Woodwardian Museums from Kirkby Moor Flags of Benson Knot).
1891. *Pasceolus Goughi*, Woods: Cat. Type Foss. Woodw. Mus., p. 2.
1897. *Pasceolus Goughi*, Roemer: Lethæa Geognostica, Th. i, Bd. 1, p. 296.

There are four specimens of this form labelled by Salter *b* 53, *b* 54, all of which are from the Kirkby Moor Flags of Benson Knot. They were figured by McCoy (op. cit. supra) as an "undetermined fossil," but not described by him. Salter, in his Catalogue (loc. cit. supra), places McCoy's figures in the margin opposite the reference to these specimens which he calls *Pasceolus Goughi*, and merely notes that "the genus has been described by Billings from Canada." McCoy had only remarked in the reference to the figures on his plate that the fossil was common in the Upper Ludlow rocks of Kendal.

Dr. Hinde (op. cit. supra), in mentioning the problematical *Favospongia Ruthveni*, refers to these figures given by McCoy as representing this latter species, but does not state that they were designated *Pasceolus Goughi* by Salter in 1873.

There has thus been considerable confusion about this form. In the first place, our Woodwardian Museum specimens are undoubtedly those figured by McCoy in 1854 and referred to by Salter in 1873 as *Pasceolus Goughi*; secondly, the name *Favospongia Ruthveni* appears first, as Dr. Hinde informs me, in John Morris' own interleaved copy of his "Catalogue of British Fossils" (ed. 1854) as a manuscript entry in Morris' own hand on an interleaf amongst the Amorphozoa in the following way:—

> "Favospongia, Salter, 1861.
> Danbyi, *Tetragonis*.
> Ruthveni, Salt.: M.G.S., p. 136.
> Pal. Fo. W. M., Pl. i D, fig. 9."

This entry is apparently meant to record the occurrence of *Favospongia Ruthveni* and *Tetragonis Danbyi* (the latter of which

[1] Lankester: Mon. Old Red Sandst. Fishes (Palæont. Soc.), 1868, p. 25, pl. ii, figs. 4, 4*a*.

McCoy figured and described in his Synopsis). The date 1861 appears to point to Salter having created the genus *Favospongia* in that year, and the reference to McCoy's figures of an "undetermined fossil" that he applied the name to this form. But Dr. Hinde has not been able to find out to what "M.G.S., p. 136" refers, and the designation of the fossil as *Favospongia Ruthveni* does not seem to have appeared in print before the name *Pasceolus Goughi.*

Six specimens, Dr. Hinde informs me, in the Geological Society's Museum, Burlington House, are mounted on one tablet and labelled "*Favospongia Ruthveni*, Salter; Upper Ludlow Rock, Benson Knot," but the writing is not in Salter's hand. Another tablet with a single specimen is marked (apparently in the same handwriting as the other) "*Favospongia* (a sponge), Upper Ludlow, Kendal, Professor Sedgwick, Figd. in Synopsis." The specimen in the Jermyn Street Museum entered as 'sponge' in the Catalogue (loc. cit.) is inscribed on the back "Collected by Ruthven from Upper Ludlow at Benson Knot," and Dr. Hinde informs me that it is the same form as that named *Favospongia Ruthveni* in the Geological Society's Museum. Unfortunately nothing further is known about this Jermyn Street specimen.

Finally, Dr. Hinde has kindly compared the Cambridge specimens labelled *Pasceolus Goughi* with these in London, and states that there is no doubt that they are identical, and that it is the same form to which the two names *Pasceolus Goughi* and *Favospongia Ruthveni* have been given.

As to the correct generic name to adopt, Dr. Hinde is of the opinion that "both are alike unsuitable, for *Favospongia* implies that it is a sponge, which in my opinion it is not; and *Pasceolus* that it belongs to Billings' genus, and this again is highly doubtful, though less improbable than its sponge affinities." Dr. Hinde writes further that on comparison with genuine specimens of Billings' *Pasceolus* collected from Anticosti, he does not think that *F. Ruthveni=P. Goughi* should be included in Billings' genus.

It appears to me advisable to adopt the generic name *Favospongia* in preference to *Pasceolus,* firstly, because it does not commit one to identifying this form with Billings' genus, to which it appears that it does not probably belong; and secondly, because the name *Favospongia,* in spite of its objectionable suggestion of affinity with sponges, has not been applied to any other fossil,[1] and is practically a new name including only this one species. The specific name *Goughi,* having appeared in print before that of *Ruthveni,* must, however, be adopted. We must wait for further knowledge of the structure of this form to determine its true affinities, and if it has ultimately to be assigned to some previously established genus the name *Favospongia* must be dropped. For the present, however, it serves the useful purpose of designating a peculiar fossil which cannot be placed with certainty in any well-defined genus. The description of its characters is necessarily meagre.

[1] Zittel in his Handbook of Palæontology does not give it.

Diagnosis.—Body hemispherical; base flattened, slightly convex in middle as if for attachment. Whole surface, including base, covered with a reticulating network of polygonal cells of irregular shape and unequal size; many are hexagonal or pentagonal, and in one specimen (*b* 53) they are subequal in size. General superficial appearance resembles *Favosites*. No internal structure known.

Measurements.—Diameter of most perfect specimen, 30 mm.; height, 17 mm.

EXPLANATION OF PLATE XVIII.

Fig. 1.—*Monticulipora poculum*, Salter. Wenlock Limestone: Dudley. Fletcher Collection. × $1\frac{1}{2}$.
,, 2.—A part of the same, showing longitudinal section near margin. × 10.
,, 3.—A part of the same, showing spiniform and polygonal corallites. × 10.
,, 4.—*Trachypora* (?) *Seeleyi*, Salter. Wenlock Limestone: Dudley. Fletcher Coll. × 2.
,, 5.—A part of the same. × 5.
,, 6.—*Pasceolus* (?) *hospitalis* (Salter). Middle Bala: Onny River. × $1\frac{1}{2}$.
,, 7.—A part of the same. × 4.
,, 8.—*Graptotheca catenulata*, Salter. Lower Ludlow: Leintwardine. Nat. size.

II.—Note on *Nautilus robustus*, Foord & Crick.

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

The species *Nautilus robustus* was founded[1] by Dr. Foord and myself upon three examples in the British Museum collection, bearing respectively the register numbers 37,010, 37,005, and C. 1,944.

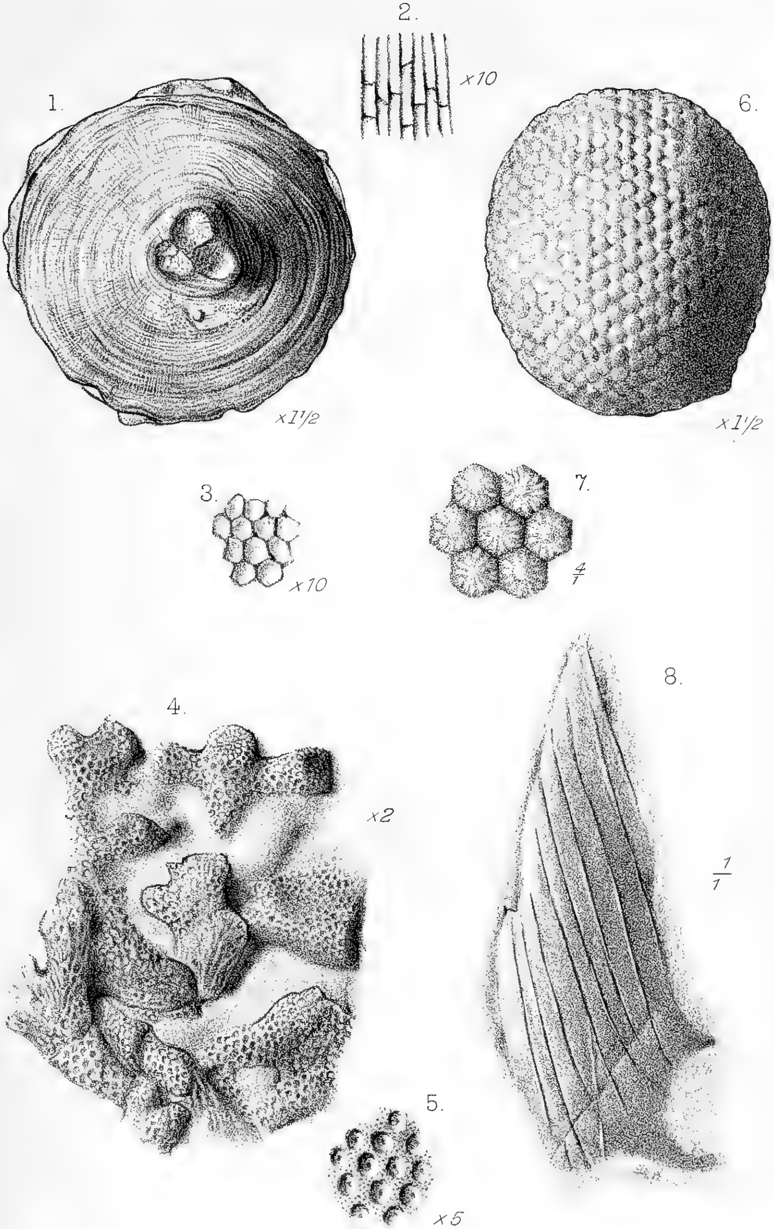
The specimen numbered 37,010 was regarded as the type (see accompanying Figures). It originally formed part of the Tesson Collection, and is stated to be from the "Inferior Oolite, Les Moutiers, Normandy." The horizon, however, given by us in our original description, and subsequently also by Dr. Foord in his "Catalogue of the Cephalopoda in the British Museum (Natural History)," vol. ii, pp. 205-7, is "Upper Lias."

The example bearing the number 37,005 belonged also to the Tesson Collection, and was labelled "*Nautilus inornatus*, d'Orb. Lias supérieur, Curcy." The third specimen, which is numbered C. 1,944, lacks any information as to the horizon and locality whence it was obtained, but it is probably a British fossil.

Quite recently Mr. S. S. Buckman informed me that there were two examples of this species in the Cheltenham College Museum, and through the kindness of the authorities of the College, to whom I desire to express my sincere thanks, the specimens have been sent to me for examination, so that I have been able to compare them with the type-specimen. The larger specimen is labelled in Mr. S. S. Buckman's handwriting, "Marlstone. Loc: unknown; but probably near Cheltenham, and possibly Alderton Hill."[2] The

[1] A. H. Foord & G. C. Crick: Ann. & Mag. Nat. Hist., ser. vi, vol. v (1890), p. 271, fig. 5.

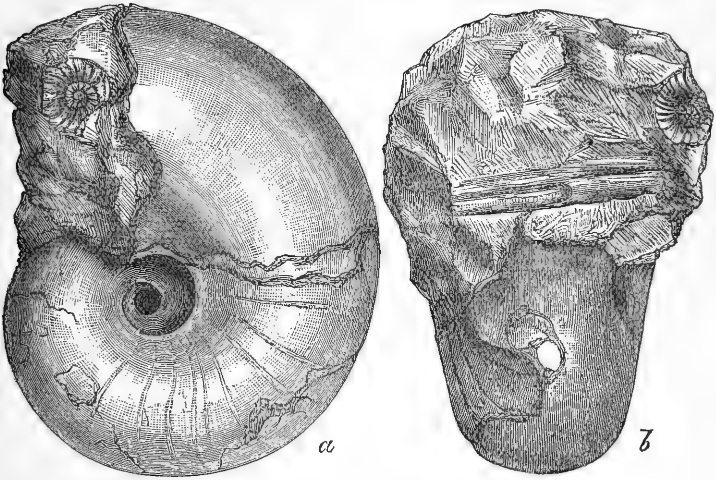
[2] Mr. Buckman tells me that this is "perhaps the *Nautilus obesus* mentioned in 'Geology of Cheltenham,' ed. 2, p. 40."



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

Silurian Fossils, *Woodwardian Museum.*

other specimen bears an original label with the inscription "Nautilus, Marlstone. Gretton."[1] Fully agreeing with Mr. Buckman's identification of these specimens, I was led to enquire into the geological age of the examples in the National Collection, for if the Cheltenham College specimens are correctly identified, it would seem that the species belongs to the Marlstone or Middle Lias, rather than to either the Upper Lias or to the Inferior Oolite.



Nautilus robustus.—*a*, lateral view, showing the cast of part of the body-chamber, the test being present in the septate part of the shell, where a few lines of growth are indicated ; *b*, front view. Middle Lias : Les Moutiers, Normandy, France. Drawn from the type-specimen in the British Museum collection [No. 37,010]. Rather less than one-third natural size.

As already stated, one of the examples on which the species was founded, viz., the specimen in the British Museum bearing the register number C. 1,944, lacks any information respecting the horizon and locality whence it was obtained. Its matrix, however, agrees with that of the specimen in the Cheltenham College Museum that is labelled "Marlstone. Loc: unknown ; but probably near Cheltenham, and possibly Alderton Hill." It is therefore more than probable that this fossil is a British specimen, and that it came from the Marlstone.

As mentioned above, the specimen regarded as the type, and figured, originally formed part of the Tesson Collection. It has the following measurements: diameter (without test near aperture), 204 mm.; thickness (without test on each side), 136 mm.; width of umbilicus (test present on each side), 33 mm. One-third of the last whorl is occupied by the body-chamber. The specimen does

[1] In regard to this specimen Mr. Buckman writes me as follows: "The label is one of my father's; the writing on it is very similar to his. Many specimens in the Museum were presented by my father, and it is therefore quite likely that he collected this specimen himself."

not bear an original label, but is numbered 37,010, and has been registered as "Nautilus sp., Inferior Oolite, Les Moutiers, Normandy." As stated in the remarks appended to the original description of the species by Dr. Foord and myself, a figure of the type-specimen was submitted to Dr. Paul Fischer, of the Museum of Natural History, Paris, who kindly replied to the effect that he found no form either in the Museum of Natural History, the Museum of the École des Mines, nor in that of the Sorbonne, which could be identified with certainty with our specimen. He observed that it resembles perhaps some specimens of *Nautilus Toarcensis*, d'Orb., but that the umbilicus in the latter appears more open and the aperture more dilated, remarks with which we fully concurred. The affinities of the species being nearest to *Nautilus Toarcensis*, d'Orb., from the Upper Lias, and the specimen numbered 37,005, being apparently specifically identical and bearing an original label indicating that it came from the Upper Lias, it seemed most probable that the new species belonged to the Upper Lias. But there are portions of other fossils preserved in the matrix, among them being a portion of a Belemnite, and a fairly good impression of an Ammonite (see Figures). A plaster squeeze of this Ammonite was taken, and submitted—the specimen being registered as from the "Inferior Oolite"—to Mr. S. S. Buckman for his opinion, and he very kindly replied as follows:—"It is certainly a *Paltopleuroceras*, and is nearest to *Am*: *costatus nudus*, Quenst. Jura, Pl. 21, f. 3, which Hyatt made type of his *Pleuroceras pseudocostatum*, Bull. Mus. Comp. Zool. Foss. Ceph. No. 5, p. 90, 1867. It is also near to the specimen figured by Quenst[edt] Schwäb. Amm. Pl. 42, fig. 19 *only* as *A. costatus nudus*; but this is a different form from that of the Jura. . . .

"Your specimen is exactly identifiable with specimens which are not uncommon in the marlstone of Dumbleton (Alderton Hill) near here [Cheltenham], and at South Petherton—specimens which for want of a better name I have called *Paltopleuroceras nudum*; these specimens are characteristic of Middle Lias (Marlstone), and of the Spinati η. That is therefore the date of your *N. robustus*. . . .

"Quenstedt called his species *nudus* as being without *spines*. Yours has, I think, some indication of spines. I have a specimen very like yours from Mid: Lias, Tilly sur Seuilles, Calvados, and it is well-spined. Both spined and unspined forms occur at Dumbleton, etc., so this point makes no difference as regards horizon."

The present writer fully concurs with Mr. Buckman's determination of the fossil, and therefore regards the type-specimen of *Nautilus robustus* as of Middle Liassic age.

When the original description of the species was framed it was not possible to give the position of the siphuncle. Fortunately the smaller of the Cheltenham College specimens (the example from Gretton) enables us to supply this deficiency. A portion of the last whorl can be detached and the siphuncle seen very clearly. Where the height of the whorl is 49 mm., its width 56 mm., and the distance of the periphery from the preceding whorl 42 mm., the centre of the siphuncle is 13·5 mm. from the preceding whorl, and therefore 28·5 mm. from the periphery. The position of the siphuncle may therefore be described as infra-median, or, in the terminology suggested by Professor Hyatt,[1] 'intracentrodorsan.'

The other French specimen originally referred to this species, viz., the example in the British Museum bearing the register number 37,005, also belonged to the Tesson Collection, and bears an original label with the following inscription: "[*Naut*]*ilus inornatus*, d'Orbigny. [Lias] sup[ér]ieur. Curcy." It has the following measurements: diameter (without test near aperture), 166 mm.; thickness (without test on one side), 116 mm.; width of umbilicus (with test), 25 mm. These dimensions agree very closely with those of the type-specimen, the latter having the following dimensions at a diameter of 160 mm.: diameter (with test), 160 mm.; thickness, estimated at about 117 mm.;[2] width of umbilicus (with test), 26 mm. Only a small portion of the body-chamber is preserved. So far, then, as external characters are concerned, it does not seem possible to separate this example from the type-specimen of *N. robustus.* It is true that the example from Curcy is labelled "Lias supérieur," but since the Middle Lias, including beds corresponding to our Marlstone, also occurs at the same locality,[3] it is quite possible that the specimen may have come from these beds.

Of the examples belonging to the Cheltenham College Museum that we refer to this species, the larger one is stated to be from the "Marlstone. Loc: unknown; but probably near Cheltenham, and possibly Alderton Hill." The measurements are: diameter of shell (without test), 220 mm.; thickness (without test), 153 mm.; and width of umbilicus[4] (without test), about 33 mm.; from which it will be seen that this example is not only somewhat larger than the type-specimen, but it is also relatively somewhat thicker, whilst the umbilicus is relatively somewhat narrower. The smaller specimen is labelled "Marlstone, Gretton," [near Dumbleton]. It has the following dimensions: diameter (without test), 165 mm.; thickness (without test), 119 mm.; and width of umbilicus (with test on one side), 26 mm. Only a small portion of the body-chamber is preserved. These dimensions agree fairly well with those of the type-specimen at a diameter of 160 mm. Also the general characters of these fossils agree so well with those of the type, that it will probably be correct to regard the slight differences in their dimensions as merely individual variations.

It may be useful to give in tabular form the measurements of the

[1] A. Hyatt, "Phylogeny of an acquired characteristic": Proc. Amer. Philos. Soc., vol. xxxii, no. 143 (August, 1894), p. 430.

[2] One side of the fossil is broken away, so that the thickness can only be estimated.

[3] "Le type normal du Toarcien de Normandie se trouve aux environs d'Évrecy, de la Caine et de Curcy, où la zone à *Am. spinatus* supporte une argile dite à *Leptæna*, c'est-à-dire à petits brachiopodes d'aspect paléozoique, *Koninckella*, *Cadomella*, etc." (Lapparent, Traité de Géologie, 4me ed., 1900, tom. 2, p. 1089.)

[4] The umbilicus is filled with matrix.

examples which are referred to this species. I is the type-specimen from [the Middle Lias] Les Moutiers, Normandy [B.M. no. 37,010]; II, the specimen from the [Middle] Lias, Curcy [B.M. no. 37,005]; III, the example from the Marlstone, Alderton Hill? [Cheltenham College Museum, no. 900]; IV, the specimen from the Marlstone, Gretton [Cheltenham College Museum, no. 901]. (For comparison with the other examples the measurements of the French specimens are given both at their greatest diameter and also at a diameter of 160 mm. and of 128 mm. respectively.)

	I.				II.				III.		IV.	
	mm.	Ratio to diam.	mm.	Ratio to diam.	mm.	Ratio to diam.	mm.	Ratio to diam.	mm.	Ratio to diam.	mm.	Ratio to diam.
Diameter ...	204+	(100)	160	(100)	166+	(100)	128	(100)	220+	(100)	165+	(100)
Thickness ...	136+	(66·6)	117+	(73·1)	116+	(69·8)	87+	(68)	153+	(69·5)	119+	(72·1)
Width of umbilicus	33	(16·1)	26	(16·2)	25	(15)	20	(15·6)	33–	(15)	26—	(15·7)

I think it highly probable that to this species belongs also a specimen in the National Collection [No. C. 4,487] from the Middle Lias of South Petherton, Somerset. It is entirely septate, and has the following dimensions: diameter of shell (wanting test near aperture), 130 mm.; thickness of outer whorl (wanting test on one side), 78 mm.; width of umbilicus (test present on each side), 21 mm.

III.—On the Distribution of the *Glossopteris* Flora.

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

Among extra-European fossil floras, none is perhaps better known than that of the Permo-Carboniferous rocks of the Southern Hemisphere. These rocks are extensively developed in Southern India, Australia, South Africa, and South America,[1] and there can be little doubt that these regions once formed part of a great continent, to which the name Gondwana-land has been appropriately applied.

The flora of Gondwana-land differs in a remarkable degree from the contemporaneous flora of Europe and North America. The characteristic and predominant plant types in Europe in the Permo-Carboniferous period were *Calamites* among Equisetales, *Lepidodendron* and *Sigillaria* among Lycopodiales, with numerous representatives of the Filicales, and of three groups, now long extinct, the synthetic types Cycadofilices and Cordaitales,[2] and the isolated phylum Sphenophyllales. These compose what we may term the northern type of Permo-Carboniferous flora.

The *Glossopteris*, or southern Permo-Carboniferous flora, consists essentially of four types, *Phyllotheca* and *Schizoneura* among Equisetales, the fern-like plant *Glossopteris*, including *Gangamopteris*,[3]

[1] Seward: Science Progress, 1897, vol. vii, p. 198.
[2] Scott: Trans. R. Soc. Edinb., 1902, vol. xi, pt. 2, p. 331.
[3] Etheridge: Proc. Linn. Soc. N.S. Wales, 1894, ser. II, vol. ix, p. 228.

and representatives of a genus, of at present unknown affinities, but probably belonging to the Cordaitales, *Noeggerathiopsis*.

In India, all these four types occur in the Panchet and Damuda series of the Lower Gondwanas.[1] In Australia, *Glossopteris* and *Phyllotheca* are abundant in the Newcastle series of New South Wales, and in other localities and horizons.[2] *Phyllotheca* was first described by Brongniart[3] from Australian specimens. *Noeggerathiopsis* also occurs in Australia, but *Schizoneura*, although recorded,[4] is apparently rare.

In South Africa, three of these types are found,[5] and stems agreeing very closely with the Indian *Schizoneura* have been recognized.[6] It may be also pointed out that a fossil, discovered by Bain in the Roggeval (Fish River), South Africa, and described and figured by Sir Joseph Hooker[7] in 1852, has some of the characteristics of a *Schizoneura*. This specimen is preserved in the museum of the Geological Society of London, where I have recently examined it. It shows two whorls of linear-lanceolate leaves united into a cup or sheath at the base. The two whorls, however, are quite separate, and on opposite sides of the rock-specimen; whereas in Hooker's figure, which is largely a restoration, they are represented as if in continuity and alternate. The free segments are of unequal length and breadth, and each is traversed by a few parallel and distant nerves. Two of the leaves apparently show some signs of splitting towards the apex. The stem characters are unfortunately not shown, and it is therefore not possible to definitely refer the African specimens to the genus *Schizoneura*, as the evidence of the leaves alone somewhat suggests.

In South America, all the chief members of the *Glossopteris* flora have been recorded in recent years,[8] with the possible exception of *Schizoneura*.

The floras of the various regions of Gondwana-land are therefore all of the same type. Recent researches have also shown that many cases of specific identity occur among the fossil plants of these widely separated areas. *Glossopteris Browniana*, Brngt., is found in India, Australia, and South Africa,[9] *Glossopteris* (*Gangamopteris*) *cyclopteroides*, Feist., and *Noeggerathiopsis Hislopi* (Bunb.), in India, South Africa, and South America, and possibly also in Tasmania. A close identity exists also between other members of the *Glossopteris* flora, as is shown by the occurrence of *Neuropteridium*

[1] Feistmantel: Foss. Flora Gondwana System, 1881, vol. iii: Pal. Indica.

[2] Feistmantel: Mem. Geol. Surv. N.S. Wales, 1890, Pal. No. 3. David: Proc. Linn. Soc. N.S. Wales, 1894, ser. II, vol. ix, p. 249.

[3] Brongniart: Prodrome Hist. végét. foss., 1828, pp. 151 and 175.

[4] Etheridge: Rec. Geol. Surv. N.S. Wales, 1893.

[5] Zeiller: Bull. Soc. géol. France, 1896, ser. III, vol. xxiv.

[6] Seward: Q.J.G.S., 1897, vol. liii, p. 324.

[7] Hooker: Trans. Geol. Soc., ser. II, vol. vii (pub. 1856), p. 227, pl. xxvii, fig. 1.

[8] Szajnocha: Sitz. k. Acad. Wiss. Wien, 1888, Bd. cxvii, p. 219. Kurtz: Revista del Museo de la Plata, 1894, vol. vi, p. 123; 1899, vol. x, p. 43; Geol. Mag., 1896, p. 446. Bodenbender: Zeit. Deut. Geol. Ges., 1896, Bd. xlviii, p. 743.

[9] Zeiller: Bull. Soc. géol. France, 1896, ser. III, vol. xxiv, p. 349. Seward: Q.J.G.S., 1897, vol. liii, p. 315.

validum, Feist., in India and South America, and *Sphenopteris polymorpha*, Feist., in India and Australia.[1]

For many years the *Glossopteris* flora was regarded both as confined to Gondwana-land, and as entirely distinct in type from that of northern latitudes. It has, however, become more and more clear that neither of these assumptions is correct. *Phyllotheca deliquescens* (Göpp.), of the Permian of Russia, also occurs in Australia, where it was first described by McCoy in 1847, under the name of *P. Hookeri*.[2] In 1898 Amalitsky[3] recorded *Glossopteris* itself from the Upper Permian of Russia, and more recently the *Noeggerathiopsis Göpperti* (Schm.) of Russia was shown to be identical with an Australian fossil plant.[4] These facts would seem to point to the conclusion that a migration into Europe of the southern type of flora took place towards the close of the Permo-Carboniferous period; a theory which is supported by the occurrence of a *Schizoneura* of very similar characters to the Indian form[5] in the Bunter of the Vosges, and of *Phyllotheca* in the Lower Oolites of Italy. In fact, all the four main types of the flora of Gondwana-land are known to have been present in Europe in either Permian or Lower Mesozoic times.

But perhaps the most interesting result arising from recent researches is the fact that the Permo-Carboniferous flora of the Southern Hemisphere can no longer be regarded as entirely distinct in type from that of Europe and North America. This flora is now known to have been composed of a mixture of both southern and northern types in at least two of the four great districts composing Gondwana-land. Such association has been completely demonstrated in South America,[6] and South Africa,[7] and there is reason to believe that it is not altogether wanting in Southern India.[8] We may therefore conclude that land connections existed in Permo-Carboniferous times between the northern and southern continents. In Africa, we can clearly trace such connections, for Potonié[9] has shown that *Glossopteris* occurs in German and Portuguese East Africa, and Zeiller[10] has described typical European Coal-measure species from the Tété Coal Basin of the Zambesi region. Further south still, in the neighbourhood of Johannesburg, an association of both these types occurs.[11]

It is a point worthy of special attention that Australia, so far, remains an exception, in that no trace of any such association of typical members of the *Glossopteris* flora with northern types

[1] Arber: Q.J.G.S., 1902, vol. lviii, p. 12.
[2] Arber: ibid., p. 17.
[3] Amalitsky: Trav. Soc. nat. St. Pétersbourg, 1898, vol. xxviii. Zeiller: Bull. Soc. Bot. Fr., 1899, vol. xlv, p. 392.
[4] Arber: ibid., p. 17.
[5] Seward: Fossil Plants, vol. i, p. 293.
[6] Zeiller: Bull. Soc. géol. France, 1895, ser. III, vol. xxiii, p. 601.
[7] Seward: Q.J.G.S., 1897, vol. liii, p. 315.
[8] Arber: Geol. Mag., 1901, Dec. IV, Vol. VIII, p. 546.
[9] Potonié: Sitz. Gesell. naturf. Freunde, Berlin, 1899, p. 27.
[10] Zeiller: Ann. Mines (8), Mém., 1883, vol. iv, p. 594.
[11] Seward: ibid.

has ever been demonstrated in the Permo-Carboniferous rocks of that continent. Northern types have, however, long been known to occur in Australia in Pre-Carboniferous times.[1] The remarkable absence of such association has recently been called into question. In discussing a paper on some Australian plants, which I laid before the Geological Society recently, Professor Boyd Dawkins[2] stated that he had himself observed the association of *Glossopteris* and *Lepidodendron* in New South Wales. On inquiry, I found that Professor Boyd Dawkins had no specimens to bring forward in support of his assertion, but he kindly gave me particulars of the locality in which he stated such association occurred, with full liberty to make use of the information. The horizon in question was the kerosene shale beds about six miles from Hartley, on the railway between that place and Lithgow, and to the west of Wallerawang. Inquiry was kindly made into this matter for me by Mr. Dun, of the Geological Survey of New South Wales. He writes that such an association is at present quite unknown in this or other districts of Australia. The Geological Survey have just completed the survey of the Lithgow-Wallerawang district, and have collected many hundreds of plant-remains from these rocks, without a trace of a *Lepidodendron* or other northern type. Neither the Survey, nor the Australian (Sydney) Museum collections, contain any specimens showing such an association of northern and southern forms, as Professor Dawkins stated occurred in the rocks of New South Wales.

The remarkable absence of northern types from the Permo-Carboniferous rocks of Australia, and especially the absence of representatives of the group Lycopodiales, would tend to show that Australia was at that time far removed from land connections with the northern continent. It is possible that an association of *Glossopteris* and some Lycopod, such as *Lepidodendron* or *Sigillaria*, may eventually be discovered in that continent, but for the present there is no evidence that any such association occurs there.

IV.—The Pyrenees at the last Geological Congress.

By P. W. Stuart-Menteath, A.R.S.M.

In recently completing, in the valley of St. Girons, and with the cordial assistance of M. Caralp, a pedestrian exploration of the Pyrenees, of which the first results appeared in the *Bull. Soc. Ramond* of 1866, it occurred to me that my view of the recently published *Compte Rendu* and the *Livret Guide* of the Geological Congress might be useful to foreign geologists.

Two Pyrenean excursions are described. That conducted by M. Lacroix is an example of the application of microscopic study in Paris to the confirmation of the observations of the colleagues of their author. He admits, in the recently published *Compte Rendu*, that these results are mistaken in regard to the age of both granite

[1] Carruthers: Q.J.G.S., 1872.
[2] Arber: Q.J.G.S., 1902, vol. lviii, p. 27 (discussion).

and ophite, and that his supposed proofs of the Jurassic age of the latter are the illusions which Pyrenean geologists have long maintained them to be. The traditions of Pyrenean exploration since 1819, which are more important than any published work that M. Lacroix has utilized, have as usual ended by removing the illusion of first impressions in his case.

M. Carez, who conducted the excursion of more strictly geological interest, similarly admits the contrary of what he has previously maintained during many years, but unfortunately he had not time to apply his conversion to the details of the extensive ground with which he deals. A confused and contradictory impression was hence inevitable regarding the most accessible, most typical, and best exposed mountain chain in Europe. Had Pyrenean geologists taken any part in the work of the Congress, this confusion would have been removed by the pointing out of decisive facts which have been ignored in attempts to controvert their results and to supersede their traditions. Practice, as opposed to theory, would have been confirmed in a fashion detrimental to the present attempt in Paris to substitute the theories of Suess for those of Elie de Beaumont and D'Orbigny, which during thirty years enabled Parisian geologists to dictate the results admissible from every local observer. The earlier theories perished through the death of their influential supporters, and because their mathematically definite outlines placed them in sharp opposition to observed facts. The latter disadvantage has been obviated in the more ingenious conceptions of theorists who are usually successful in avoiding any appeal to decisive facts.

The detailed map and sections presented by M. Carez in the *Livret Guide* are slightly modified reproductions of the work of Pyrenean geologists, selected at those points which have been most completely described and figured by them in print; but these documents were produced many years ago, and are not completed by even the additional facts of observation which were known to their authors in 1866, when I commenced the natural development of their work with their assistance and co-operation. Thus, at Salies du Salat the detailed map presented is arranged to produce the belief that no granite exists in the Cretaceous and that the salt deposits belong to the Trias formation, in accordance with theories which M. Carez has opposed to nearly all the authors of serious mapping in the Pyrenees. Yet for many years past I have several outcrops of granite marked on my working maps, and these have been described by Leymerie, Garrigou, Bleicher, and Pouech. Immediately in front of the bridge by which the excursion left the town of Salies the granite is visible to right and left for over 200 metres between Bout du Pont and the Salt Factory; and to the east, between Betchat and Jourdin, it forms bosses of 50 metres in diameter, well exposed on the left bank of the Lens stream. If any foreign geologist will visit these points he will understand the character of the assertions by which M. Carez has nullified the work of all Pyrenean geologists during the last twenty years. M. Roussel has recently admitted the presence of the intrusive granite as penetrating the Cretaceous; but he has confused the question by assuming that the red marble produced here by alteration of the Cenomanien limestone is Devonian, being unacquainted with the numerous points at which exactly similar marble is produced in the former formation with characteristic fossils in the Western Pyrenees. Two recent surveys at Salies have proved to me the identity of the ground with that of Capvern. As regards the supposed Trias, its introduction by M. Carez is equally theoretical. The fault he figures is impossible, and, in accordance with every engineer acquainted with the plans and borings of similar salt deposits throughout the Pyrenees, I regard the salt as Tertiary and connected with the ophites. It occupies a crater of explosion, excavated to more than 1,000 feet deep across all the rocks of the district older than the Oligocene, and has been deposited in that crater at about the same time as the more lagunar Oligocene salt of the entire Spanish slope of the Pyrenees. The red marls are everywhere an accompaniment of the ophite at its junction with any formation which it happens to traverse. The map of M. Carez ignores the fact that extensive volcanic breccias extend across his supposed fault, and are a common characteristic of the entire sub-Pyrenean plateau, of which the environs of Salies are merely a normal specimen. He supposes here an island, in which peculiarly destructible variegated marls could have resisted the destructive action of the Cretaceous sea, while at the Pic de Bugarach he refuses to recognize such an island in a mass of peculiarly tough dolomite. Yet no such islands can be recognized in the neighbourhood of Salies, while they are admitted to exist at three miles from the Pic de Bugarach. The most striking analogies, as well as every detail of the ground, are ignored in the theory presented to the Congress. The progress of Pyrenean geology has been hampered at every point by similar attempts to discredit all local research by the hasty reproduction of its incompletely published results.

The prolongation of the rocks of Salies is presented by M. Carez at Capvern, where the concealing diluvial sheet of the Lannemezan is removed from the underlying rock plateau. Here he admits the presence of granite, because the main road between the two thermal establishments is cut through its ramifying veins. But he assumes that the rocks which these veins cut must be Triassic, and states that the granite "seems ante-triassic." Off the high road I have found a granite vein of less than four feet in thickness, and exposed along about a hundred yards, at 700 metres north-west of the castle of Mauvezin, cutting vertically through the entire Flysch, which with characteristic composition, structure, and fucoids, forms the whole district, resting on the Cenomanien limestone, precisely as at Salies and in the entire sub-Pyrenean plateau. No practical geologist visiting Capvern, with these indications, can fail to recognize the volcanic breccias intercalated in the Flysch, which attest the Cretaceous age of the intrusions.

A few miles to the south-west, at Ossun, Adé, Julos, etc., M. Carez now admits that both granite and ophite penetrate the same Cretaceous rocks, while M. Lacroix admits the same in the *Compte Rendu* of the Congress. In the *Bulletin Soc. Geol.* of 1896 M. Carez published elaborate maps and sections representing the said Cretaceous as Cambrian and Silurian, in explicit contradiction of all previous work on the subject. As at Capvern, his sole reason was the theory that granite cannot penetrate the Cretaceous. To my objection that the slates of Lourdes, thus figured as Silurian, contain abundant *Ammonites Deshayesi* and *three closely allied* species which commonly accompany that Ammonite, he replied by assuming inexcusable blunders of surveying, and by stating in the name of M. Douvillé that my determination of the *A. Deshayesi* was a palæontological blunder (Bull. Soc. Geol., 1897, p. 463). In the *Livret Guide* he states that the *Ammonites Deshayesi* was determined by M. Douvillé, while "other authors" quoted "a whole series of distinct species." He unfortunately only recognized this Ammonite in a single quarry where I had thrown aside about two hundred specimens, amongst which I had found the three species or varieties which enabled me to confirm my determination of the *Ammonites Deshayesi*, in spite of its close resemblance to unnamed species of the Lias slates of La Spezia. It is unfortunate that the interests of M. Carez should completely mislead the Congress regarding everything concerned in a case strictly analogous to that of Capvern, where he again repeats his method of reforming the facts of observation.

Together with the representation of the Aptien as Middle Silurian and the Flysch as Cambrian, M. Carez presented in 1896 a reproduction of the panoramic view of M. Jacquot, represented as a section of the Biarritz coast. As at Capvern, he assumes the rocks beside the ophite to be Lias. I have repeatedly proved, by both maps and fossils, that these rocks are the base of the Eocene, normally overlying the Danien along at least 150 kilometres. My observations were confirmed in great detail by the Staff Officer in charge of the topographical mapping of the district, in *Bull. Soc. Geol.* of 1893, and the points left obscure by him have since been completed. M. Carez ignores the whole of this work. He represents quartz crystals in the Eocene as dipyre of the Lias, and reproduces a fault which Jacquot logically assumed in the belief that the coast between Fontarabia and St. Sebastian is a reappearance of the Cretaceous outside the Danien. I proved this coast ridge to be Eocene by a map in the *Comptes Rendus Ac. Sc.* in 1894, and by Nummulites described in *Bull. Soc. Geol.* of the same year. It is unfortunate that M. Carez does not understand the ordinary proof of a fault, but always introduces faults as imaginary lines which, if traced on a map, justify his reproducing that map as an original production by the author of the fault. His arrangement of the rocks at Biarritz has naturally led to one of those monstrous paradoxes of stratigraphy which have become a speciality in the hands of M. Marcel Bertrand. I will only here remark that M. Bergeron figures *beneath* the Danien the same supposed Trias which M. Carez figures as above it, and whose position *above* the Danien is explained elaborately by MM. Bertrand and Michel-Levy. Numerous borings, to which

I have attended for many years, and the accurate plans which they have involved, prove the normal succession which I have already mentioned as prevailing along 150 kilometres right and left of the shifting sands that frequently obscure the Biarritz coast.

Here I must pass on to the remaining sections presented to the Congress. In these, the best work of Pyrenean geologists has been altered by the method of M. Carez so as to confirm the paradoxes of M. Marcel Bertrand. Until his recent treatment of the Biarritz coast these sections of the Pic de Bugarach were the only example in the Pyrenees of that stratigraphy which M. Bertrand has described as typical in mountain chains. As published in the *Bulletin des Services* of 1889 M. Carez' sections appeared conclusive. In January, 1901, my account of a careful examination of the ground was suppressed by the *Société Géologique*; but a brief summary was rescued and read by M. de Lapparent in November, 1900, and is printed at p. 837 of the Bulletin of that year. Since then M. Carez has admitted in the *Bulletin des Services* of May, 1901, p. 65, that his chief proofs of abnormal carting of Urgonian limestone over Senonian marls are mere blunders of surveying. He had here, as in other cases, drawn sections along the strike of the rocks, and arbitrarily assumed that outcrops of intercalated Hippurite limestone were superposed blocks of Urgonian. It is the habitual employment of such methods of proving the paradoxes in question, that renders all criticism of them obnoxious and enables it to be suppressed as polemical. Worse examples could be cited in abundance, but would inevitably be useless where verification on the ground can be evaded. Under the guidance of the Congress by M. Carez, the proofs which he has since repudiated must have appeared conclusive, although the only proof which he now maintains would have appeared obviously inconclusive. The section in the *Livret Guide* represents the ridge north of Bugarach as faulted and broken, although it is a completely visible normal anticline, as correctly figured by M. Roussel. The latter observer, having studied the ground in great detail, has at all points refuted M. Carez. But it is enough to say that the Pic de Bugarach is a Palæozoic island rising out of a mantle of Upper Cretaceous deposited around it. This is proved by the fact that a similar island, admitted to be such by M. Carez, rises out of the same mantle at three miles to the north, while other islands, which M. Carez formerly misinterpreted and has been induced to admit, similarly protrude to the south and west. The relations between these islands and their mantle are precisely analogous to those of the Pic he still refuses to comprehend. The only pretext for any supposed difference lies in the absence of fossils in the Pic de Bugarach, and in the presence of some encrusting patches of Cretaceous on its surface. The section of the Pic presented to the Congress is purely ideal, it does not even attempt accuracy as regards the outward outline, its representation of the Cenomanien is in defiance of its visible arrangement, and the mere notion that such sections can decide points of extreme delicacy in stratigraphy is an outrage on practical geology which M. Carez has repeated throughout his entire work in the Pyrenees. It is remarkable that such work has been habitually selected as confirmation of the paradoxes of M. Marcel Bertrand, and has been habitually opposed to sections of extreme accuracy on a true scale. The work of Suess is in great part founded on generalizations derived from compilations of such sections, and his latest volume is unfortunately concerned with regions where such data cannot be verified and controlled in the manner which I have found possible elsewhere. In the *Mining Journal* of November 30, 1901, I have given my latest results of such verification; and such work, however obnoxious to theorists, seems to me incumbent on practical geologists who realize the importance of their science as a basis of industrial operations rather than as a source of confirmation in questions of controversial theology.

As regards the excursion from Lourdes to Gavarnie, I may remark that in 1865 M. Carez obtained from me a map of the Western Pyrenees, from the ocean to the valley of Lourdes, which appeared in the compiled map of France of Carez and Vasseur. In the *Bull. Soc. Geol.*, 1887, p. 185, I protested against the arbitrary introduction of a mass of Silurian as overlying the Carboniferous. The Survey geologists subsequently confirmed in detail the structure of the district in question as I had described it, and hence the quotation of a gigantic stratigraphical paradox was prevented in this instance, although M. Carez professed inability to understand the meaning of my protest. Similarly, the official geological map of the Pyrenees, published in 1890, represented as Cambrian the vast band of Upper Cretaceous which I figured for the map of Carez and Vasseur between Cauterets and the Pic D'Orhy. This contradiction, vigorously sustained against me by M. Marcel Bertrand in November, 1887, would have furnished gigantic examples of the *charriages* to which the latter writer attributes mountain structure; but as his reply consisted solely in insinuations of ignorance, and as I have since repeatedly proved his Cambrian to be Upper Cretaceous by admitted fossils at decisive points, it has now been admitted by the Survey geologists to be what I represented it. Since then I have made known two other bands of Secondary rocks in the Palæozoic of the official map, one north of Gavarnie and one running east and west of Argeles. Each of these is being now vaguely described without fresh proof, so I may here state that I have found five Hippurites in the band of Argeles at 1,200 metres north-west of Arcisans-Dessus, while in the band north of Gavarnie I have found the same Lias corals which characterize the base of the Argeles band at the Col d'Espandels and many other points. The Congress might thus have remarked that the Pyrenees resemble the Alps in presenting interior synclinal bands of Secondary rocks from the Trias to the Flysch, although this fact is deliberately contradicted by the official geological map of 1890, whose errors are reproduced in that of Europe which confirms the theories of M. Bertrand. It is an instructive fact that the attempts to introduce the *charriage* theory in these cases, as at the Pic de Bugarach, are preventing the publication of the details which the most experienced geologists of the Pyrenees have been long accumulating regarding the real structure of the most typical and best exposed mountain chain in Europe. Before even the most salient facts of that chain have been permitted to appear in the ordinary and essential channels of geological documentation, a theory of mountain structure derived from the elaborate compilation of Suess has been made the criterion of fact and based upon the selected errors of writers who have obtained, on various pretexts, portions of the work of practical geologists in the Pyrenees. The entire opportunity of verification afforded by the Congress has been subordinated to the interests concerned. International co-operation in such matters may only tend to confirm attempts to override observation, and to silence those who have acquired the long preliminary practice required to correct the illusory and perspective impressions of mountain structure. Parisian geologists apparently fail to realize the inconvenience of vast innovations in maps whose freedom from theoretic conjecture has frequently cost the sacrifices of a lifetime.

In the superficial geology of the Gavarnie valley the Congress was equally misled. In 1866 I proved, in the *Bulletin Société Ramond,* that the conglomerate of the Park of Pau, previously described by Charles Martins and others as a moraine of the Glacial Period, was situated at sixteen kilometres *outside* of the extreme limit of the moraines of that period, and that it represented the Oligocene ice of the Superga of Turin, with which I was familiar. Charles Martins hastened to correct his conclusions; but, assuming the opposite extreme in a theoretical map of the glacier of Gavarnie, placed the upper limit of that glacier at fully 1,000 feet below the distinct lateral moraines which can be seen to the north of Argeles by any observer who will climb the mountains. In the *Bull. Soc. Geol.,* 1868, p. 697, I figured a great fault at Gavarnie, which had been overlooked by Dufrénoy. This was adopted by Magnan, and generalized into a system which has long misled observation. At Gavarnie that fault juxtaposes a character of erosion which is common on the Spanish side, in abrupt contrast with the very different character which prevails in the French Pyrenees. The Gavarnie valley, in receding rapidly through the greater erosion on the moist and snowy French slope, has abruptly entered the Cretaceous and Tertiary sheet of the Spanish side. The same circumstance accounts for the peculiar scenery of other Pyrenean valleys, but at Gavarnie it is accentuated by the prominence of the fault and the considerable drainage of the lofty Mont Perdu. It is unfortunate that personal questions should prevent, at every point, the clear recognition of the facts of Pyrenean geology, owing to the manner in which their history has been altered in Paris in defiance of both documents and dates. The briefest statement of observations might have removed difficulties that have hampered progress for thirty years, had such statement not been rendered obnoxious by previous misrepresentations which it is impolite to notice and unpleasant to explain. In welcome confirmation of certain theories in vogue, a complete geology of the Pyrenees has been developed, to which no Pyrenean geologist can contribute without abandoning those habits of cautious statement which are essential to the integrity of his work.

Note.—Since the above was posted, in January last, the points described have been largely discussed in Parisian publications. It is admitted that the granite, ophite, and supposed Trias are above and not beneath the Cretaceous. It is hence assumed that they *must be* abnormally carted caps of those ancient formations. The entire evidence of their age being admittedly false, that age is maintained by a paradox that contradicts every detail of the district. There could be no shadow of doubt that they are beneath the Cenomanien, were it not that they are frankly eruptive, and at Salies, as at a hundred other points, flanked by lentiles of eruptive breccia intercalated in the Cretaceous Flysch. In the Alps, the abnormal carting of the Brèche du Chablais is similarly assumed, to save the assumption that its volcanic vents are Triassic by micrographic theory. M. Marcel Bertrand regarding the Alps, and M. Haug regarding the Pyrenees, have propounded theories before visiting either chain. Since first exploring the rocks of Salies with the assistance of Leymerie in 1866, I have endeavoured to sacrifice all theory to observation. Unless practical geologists cease to despise controversy, they will find, like myself, that any mention of their work is an outrage, and that any field survey is intolerable polemics. The entire geology of Asia having been yesterday reformed from Vienna, similar treatment of Alps and Pyrenees is inevitable. It is easier to silence all local observation than to repeat its task.

V.—Contributions to South African Petrography.

By F. P. Mennell, F.G.S., Curator of the Rhodesia Museum, Bulawayo.

It is remarkable, considering the enormous development of igneous rocks in South Africa, that so little has been written concerning the features they present in the field or under the microscope. Right away from Cape Town into the tropics, plutonic masses, dykes, and lava-flows interrupt the continuity of the sedimentary deposits with astonishing frequency. Some of these rocks, like the Cape Town granite and dolerite, are probably of pre-Silurian age;[1] others, like the Kimberley lavas, were erupted during the Secondary period; while others, again, like the dykes and lavas of the Zambesi Valley, are probably of late Tertiary or even geologically recent date, as evidenced by the numerous geysers and hot springs[2] which represent the final phase of not long antecedent volcanic activity. They appear to bear the same relation to the volcanoes of Central Africa as the British Tertiary lavas do to those of Iceland.

[1] They are overlain unconformably by a thick formation which is itself older than the earliest fossiliferous beds (Devonian) of South Africa.

[2] See Ferguson on the geysers of the Zambesi and Kaful Valleys, Proc. Rhodesia Sci. Assoc., 1902.

In the present chaotic state of petrological nomenclature it is necessary to explain the significance of the terms employed in describing the rocks. No system of classification can be regarded as wholly satisfactory, but it certainly seems hopeless to rely on such features as the presence or absence of particular minerals. Such a course brings together types which differ widely in chemical composition, and separates others which are chemically and genetically closely related. In the brief notes which follow, the grouping depends solely on mode of occurrence and chemical composition, a method of classification which appears to be steadily gaining ground owing to its simplicity. The significance of the nomenclature, which accords strictly with the classification adopted, will be readily perceived from the following table, names in general use being employed as far as possible and simply endowed with greater precision. In individual cases the name of the most characteristic mineral is prefixed for purposes of distinction.

	Eruptive (= Lava-flows).	Intrusive (= Dyke rocks).	Plutonic (= Rock consolidated at great depths).
Acid	Rhyolite ...	Granophyre ...	Granite
Sub-acid ...	Trachyte ...	Felsophyre ...	Syenite
Sub-basic ...	Andesite ...	Porphyrite ...	Diorite
Basic	Basalt ...	Dolerite ...	Gabbro

With these preliminaries we may pass on to the rocks themselves. In South Africa as elsewhere, acid lavas and basic plutonic rocks are rare, while basic lavas and acid plutonic masses are developed on an enormous scale. The only rhyolite which has come under my notice occurs near the Express Mine in the Umniati district of Mashonaland. It shows sparingly distributed phenocrysts of hornblende and orthoclase felspar with rarer quartz, set in a glassy groundmass crowded with globulites, margarites, and longulites. Partial devitrification is evidenced by a cloudiness between crossed nicols, but there are no signs of spherulitic structures. Ilmenite and brilliantly polarizing sphene occur as accessories, but neither is abundant.

Sub-acid lavas appear, like the rhyolites, to be poorly represented, and I am not able to refer any rocks to this division with anything like certainty. There are also a number of lavas probably belonging to the andesites, but in the absence of analyses discrimination from the basalts is a matter of considerable difficulty. A 'melaphyre'[1] from the Kimberley Mine at Kimberley belongs, however, to this class. It is a fine-grained aggregate of lath-shaped felspars with some interstitial chlorite, etc., which may partly represent originally vitreous material. Some of the felspar is untwinned, and is probably orthoclase, while the twinned crystals seem to be andesine. There is no porphyritic constituent, and the amygdaloidal cavities, which are lined with chlorite and filled with chalcedony or with calcite, are the most interesting feature of the rock. Another and rather more basic andesite occurs interstratified with sandstone

[1] This is obviously a different rock to that described by Stelzner.

at Taba s'Induna, a conspicuous hill about 12 miles north of Bulawayo. The under part of the flow is highly amygdaloidal, but the scoriaceous upper portion was evidently denuded off before the deposition of the overlying rock. Sections from the compact parts of the mass show it to be made up of lath-shaped felspar with much less abundant granular augite. Glomero-porphyritic aggregates of larger felspars are distributed through the mass, and magnetite occurs as an accessory.

We now come to the basalts, and here our only difficulty is one of selection. Undoubted lava-flows are not particularly common in Cape Colony, but further north, and especially in the Zambesi Valley, they are developed on an extensive scale. A rock from Livingstone Island at the Victoria Falls may be taken as typical. It shows a flow structure which is by no means so clear under the microscope as on a polished surface, but is indicated by the distribution of coarse-grained glomero-porphyritic aggregates of augite and labradorite. The bulk of the rock is a granular mixture of augite, plagioclase, and magnetite, with some interstitial matter, the ophitic structure not being developed in any of the specimens I have examined from this extensive area. Another example from

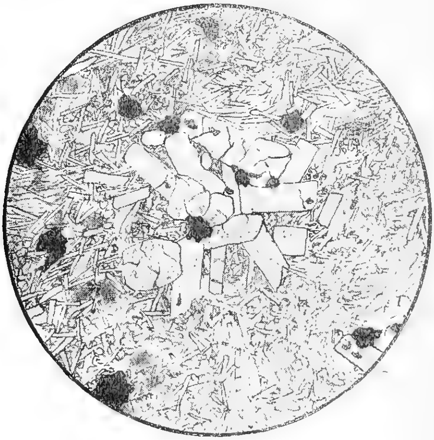


Fig. 1.

the north bank of the river at the Falls is not so fresh, but otherwise quite similar. Some varieties are highly amygdaloidal, the cavities being filled with pectolite and other zeolites as well as calcite, agates, etc. The individual flows can frequently be distinguished by the occurrence of bands of these amygdules at intervals in the great masses of lava. A specimen from the Dekka River on the Falls Road presents some interesting features (Fig. 1). Resinous-looking crystals of felspar are obvious to the naked eye; indeed, they occasionally attain a length of $\frac{1}{2}$ inch, and under the microscope these are seen to form part of glomero-porphyritic aggregates which also comprise good-sized crystals of colourless augite and a few rounded grains of olivine, this being the only case in which I am able to record olivine from the rocks of the Zambesi Valley. The groundmass is largely of the usual type, a granular aggregate of lath-shaped felspar, augite, and magnetite, but there is also a considerable amount of glassy material, which is either brown in colour and isotropic, or bright orange, with an imperfect spherulitic structure between crossed nicols.

Though by no means the most abundant type, South Africa affords some good examples of olivine basalt. A beautiful one[1] occurs amongst the rocks which surround the volcanic pipes of the Kimberley diamond-mines, from which they were no doubt originally extended. It is holocrystalline, with a well-marked ophitic structure, and I know of no rock in which the distinction between olivine and the pyroxenes is so well indicated. Both augite and enstatite are present, and their cleavages are well developed, pinacoidal ones being shown by both rhombic and monoclinic variety in addition to that parallel to the prism. Twinning is very common, and the felspars penetrate the crystals in all directions. The olivine, on the other hand, shows distinctly higher refraction and stronger double refraction than the pyroxenes, and the absence of cleavage is in striking contrast to its conspicuous development in their case. It occurs in rounded grains and granular aggregates, which are not as a rule penetrated by the felspars, and are traversed by irregular cracks, sometimes rendered more apparent by incipient serpentinization, though in no case has this proceeded far. The felspars give lath-shaped sections showing repeated twinning, and evidently belong to a variety near anorthite, the maximum extinction angle being about 40°. There are also larger allotriomorphic crystals, which are untwinned but are strongly zoned in layers of different composition. Rather large irregular granules of ilmenite are somewhat sparingly distributed, and perofskite also appears to be present as an occasional accessory.

We now come to the consideration of the dyke rocks, which are more evenly distributed among the various types. I have adopted the term granophyre for the acid division, as it is etymologically a highly appropriate term, but not without some misgivings owing to its having unfortunately been restricted by many authors to those rocks in which the groundmass assumes a micrographic structure. Quartz felsite would perhaps be less open to objection in some respects, but any such double-barrelled expression is very cumbrous when a prefix becomes necessary. With this explanation I do not think that my usage of the term need give rise to any misconception.

Some beautiful granophyres, in the ordinary acceptation of the word, occur near Fort Gwelo in Matabeleland. Large phenocrysts of felspars (chiefly plagioclase), and more rarely of corroded quartz, are set in a groundmass which is partly spherulitic and partly 'microgranitic.' The former type largely predominates, and the spherulites are frequently seen to be composed of radially disposed

[1] This is no doubt the rock referred to by Professor Bonney, Geol. Mag., 1897, p. 449.

micrographic intergrowths of quartz and felspar; indeed, under a high power most of them are resolvable into micropegmatite. Large flakes of biotite occasionally occur, and smaller, sometimes idiomorphic, crystals of hornblende are also present. Both ferro-magnesian minerals are somewhat decomposed, chlorite and calcite occurring as alteration products. The felspars are beautifully zoned and for the most part very fresh. They frequently form a nucleus for the spherulites, or the latter may diverge from their angles.

Another type of granophyre occurs in Northern Rhodesia (British Central Africa), near the junction of the Chibwe and Zambesi Rivers. It shows good-sized phenocrysts of felspar, and smaller ones of quartz, set in a purplish groundmass. It bears a considerable resemblance to the well-known 'quartz porphyry' which occurs so abundantly as boulders in the New Red Breccia near Teignmouth in South Devon. The groundmass is, however, of a finely granular type, and is by no means so red. Both quartz and felspar occur in idiomorphic but corroded crystals, and the latter seems almost entirely referable to microcline, though decomposition has obscured the cross-hatching in many cases. Magnetite and sphene are abundant accessories, while there are also occasional prisms of zircon.

At Francistown, in Bechuanaland, occurs a granophyre in which hornblende is the principal porphyritic constituent. A second generation belongs to the groundmass, which is, however, composed principally of quartz and felspar with abundant apatite and sphene. The quartz, though not thoroughly idiomorphic, occurs in grains and granular aggregates, and almost invariably presents convex boundaries to the felspar. Orthoclase predominates, but twinned plagioclase is also present.

A rock which has quite a granitic appearance in hand-specimens occurs at the Dopodge River near Waukie, in Northern Matabeleland. It shows large porphyritic felspars, which are seen under the microscope to be orthoclase. They are frequently twinned on the Carlsbad plan, and often show rounded inclusions of quartz. Plagioclase is also present. Both muscovite and biotite occur, sometimes as aggregates, and the latter is largely chloritized. The groundmass, which does not make up a very large bulk of the rock, is partly micrographic and partly micropegmatitic. In the latter case the quartz is of what has been called the 'vermicular' type, being rounded and showing a wavy outline in longitudinal sections.

The designation felsophyre has been adopted instead of the very ambiguous term felsite for the dyke rocks corresponding to the syenites. A number of the 'amygdaloidal diabases' and 'felsites' of Cape Colony no doubt belong to this division, but without chemical analyses it is difficult to assign them to their proper position. A large intrusion near Belingwe, in Matabeleland, may, however, be referred here with some certainty (Fig. 2). It consists of idiomorphic felspars (orthoclase and oligoclase) imbedded in a 'felsitic' groundmass, stained with chlorite, representing the original ferro-magnesian mineral. The orthoclase is identified by the simultaneous straight extinction of the two halves of a Carlsbad twin, while the oligoclase gives a maximum extinction angle of about 10°, and is nearly always twinned on the pericline as well as the albite type. The prism faces are well developed, especially in the orthoclase, and the crystals are usually elongated in the direction of the vertical axis. A few grains of ilmenite occur in the groundmass. Another rock from Belingwe may be referred to the porphyrites. It is very similar to the last in appearance and structure, but is obviously more basic. Andesine is the predominant porphyritic felspar, and patches of chlorite appear to represent a ferro-magnesian constituent which was also possibly porphyritic. Numerous granules of leucoxene indicate the presence of original ilmenite, and apatite also occurs in shortish prisms. Epidote and calcite are decomposition products.

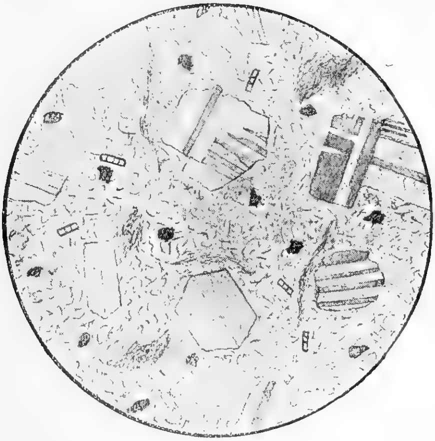


Fig. 2.

Quite another type of porphyrite is represented by a specimen from the Modder River. It consists of an aggregate of fair-sized lath-shaped felspars, with elongated crystals of augite, largely chloritized, granules of ilmenite, small but numerous, and a good deal of glass. The last is of quite a bright green colour and perfectly isotropic, but it encloses numbers of minute colourless spherulites, which never give a black cross in polarized light, but show an extinction curve exactly similar to the 'brushes' of a biaxial interference figure. The felspar seems to be mostly andesine. Like many of the South African dyke rocks this example is amygdaloidal. The amygdules are almost spherical as a rule, and are made up of calcite and quartz, sometimes intermixed, with a border of feebly pleochroic chlorite. Crystals of pyrites occur as inclusions in the calcite.

We now come to the dolerites, which present great diversity of structure. Glassy examples occur at the Criterion Mine not far from Bulawayo and at the Bonsor Mine in the Selukwe district of Matabeleland. At the former locality the intrusion appears to be completely glassy. It is considerably altered, being practically a 'palagonite,' but the mass of the rock is quite isotropic, though it is crowded with crystallites (longulites) and minute specks of magnetite. It shows occasional rather irregular spherulites. At the Bonsor Mine the glass forms the margin of an intrusion into quartz schist, and becomes rapidly more crystalline and apparently also more basic as it is traced from the contact. About an inch from the edge it is dark brown in colour, and crowded with crystallites and tiny microlites. It shows also idiomorphic phenocrysts of augite and more or less corroded felspar, the latter evidently a basic variety and largely converted into epidote.

The more crystalline varieties are usually of the granular type and do not as a rule contain olivine. The dykes which pierce the Cape Town granite afford good examples. They consist of lath-shaped felspar, augite, rarely idiomorphic, but of prior consolidation to the felspar, magnetite, ilmenite, and a little interstitial matter. Chlorite occurs as a decomposition product of the augite. The felspar appears to be labradorite, and one specimen of the rock gave a silica percentage of 52·41.[1]

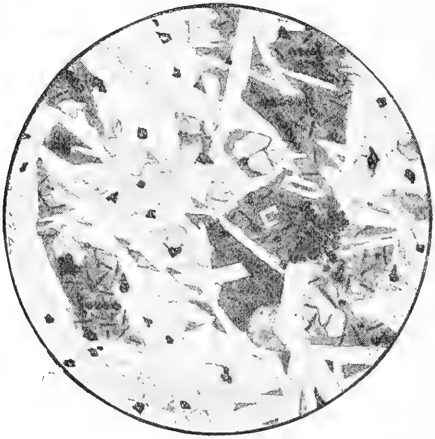


Fig. 3.

A very similar rock, but with a good deal of glassy matter, penetrates the Matopo granite mass near Forest Vale (Fig. 3). The glass is brown in colour and quite isotropic. It is crowded with little rods of magnetite, very long and thin, while skeleton crystals of felspar are also of frequent occurrence. Magnetite is very abundant all through the rock and is almost invariably idiomorphic, little octahedra being common which are frequently grouped in rows, sometimes apparently along the edges of a cube. The lath-shaped felspars often show bifurcated terminations and inclusions of the groundmass. This rock is near the margin of one of the outliers of Tertiary (?)

[1] Cohen: N.J. für Min., 1874. See also Shaw: Proc. S.A. Phil. Soc., vol. i, pt. 2 (1879), p. 59.

sandstone which rest unconformably on the Bulawayo schists and the marginal portions of the Matopo granite mass. These are evidently of the same age as the coal series and associated beds of the Zambesi Valley, from which several lavas have been described. A dyke penetrating the sandstone itself at Mafungaburi Peak, Matabeleland, is of the same type, but contains a smaller proportion of glass, while the crystalline constituents are of larger size. The augite is frequently idiomorphic, and is of prior consolidation to the felspar. Good-sized rods of magnetite are abundant, but do not show the definite outlines of the Forest Vale variety. Another rock from the Zimba River, Northern Rhodesia, is holocrystalline and rather coarser-grained. The felspars frequently show pericline as well as albite lamellation, and must be nearly related to anorthite. The augite occasionally shows crystal outline, and microlites occur as inclusions in the felspar, but the latter sometimes penetrates the larger crystals. Rods of magnetite are freely scattered through the mass, and apatite is also present.

A transition to the ophitic structure is seen in a specimen from the Waterworks, about 4 miles from Bulawayo. It consists of large plates of augite, for the most part in a beautifully fresh condition, and very decomposed felspar. It seems evident that the augite originally tended to be porphyritic, but when the felspar commenced to crystallize out, crystals continued to grow instead of a second generation forming in the groundmass. This is shown by the fact that the felspars never occur as inclusions in the augite, and seldom penetrate more than a very short distance from the margin of the crystals. If there was originally any glassy matter it is now lost in the confused mixture of decomposition products due to the alteration of the felspar. Ilmenite is abundant, and sometimes shows fine examples of skeleton crystals, while a colourless mineral with very strong refraction and double refraction is probably sphene.

A beautifully fresh ophitic olivine dolerite occurs near Fort Gwelo, Matabeleland, on the Sebakwe Road. The felspar gives the usual lath-shaped sections in most cases, and frequently shows pericline lamellation. The augite is penetrated by the felspar in all directions, and often occurs in aggregates. The olivine is rarely penetrated by the felspar, and shows a rougher surface and higher interference tints than the augite. The cleavage is occasionally shown, and the mineral is traversed by the usual irregular cracks, which are now and then rendered more prominent by incipient serpentinization. A curious feature is the enclosure in the olivine of small crystals of a brownish pleochroic hornblende with well-developed cleavage. A few minute flakes of biotite also occur. Both these minerals are usually associated with grains of magnetite.

Among the plutonic rocks the granites afford examples of a number of varieties. The coarse-grained biotite granite of Cape Town has been described by Cohen[1] and others, so that it is needless to enumerate its normal features. One variety, however, seems worthy

[1] N.J. für Min., 1874.

of mention, a graphic modification with tourmaline as an abundant accessory. The latter mineral seems to be intergrown with the felspar in a similar way to the quartz. It is a yellowish variety without marked pleochroism, and the interference tints are not masked, as is often the case, by the strong absorption. It may possibly be regarded as having replaced quartz, but it seems more likely that the intergrowth is more apparent than real, and is due to the penetration of the mineral into cleavage cracks in the already consolidated felspar. A graphic granite from Northern Rhodesia, about midway between Kalomo and Monze, may also be noticed. The felspar, which builds pink crystals several inches in length, is microcline. The quartz does not occur in well-defined skeleton crystals, but gives a somewhat irregular wavy longitudinal section and a rounded transverse one. Occasional small flakes of muscovite are present.

The great granite mass of the Matopos, which forms the backbone of Southern Matabeleland, presents some interesting features. The normal granite in hand-specimens closely resembles the Dartmoor rock (e.g. that of Hay Tor). In a rather fine-grained example from the Khami Valley the dominant felspar is, however, seen under the microscope to be microcline. It is obviously the last product of crystallization, as it even encloses the small patches of micropegmatite which occasionally occur. Orthoclase and oligoclase are also present, the former being apparently the felspar of the micrographic intergrowths. Biotite is the ferro-magnesian constituent. Sphene and apatite are the accessories. Near Bulawayo, which is situated on the contact zone, the rock assumes a very different aspect. The structure is decidedly gneissic, and the felspars are flesh-coloured. The appearance of foliation is probably due to movement before complete consolidation (Fig. 4). This seems to be implied by the granulation of the quartz and microcline[1] and the absence of deformation in the minerals of prior consolidation. It does not do, however, to place too much reliance on this feature, for, as I have previously[2] pointed out, it is precisely these minerals which most readily yield to the effects of pressure, and the quartz may be completely granulitized before the other minerals are appreciably affected. Hornblende is here the dominant ferro-magnesian constituent, though biotite is present in most slices. In the pegmatite veins which ramify through the mass and are obviously of late consolidation, microcline takes the place of the other felspars, but in the normal rock orthoclase seems to be rather more abundant and oligoclase frequently forms large pseudo-porphyritic crystals. Sphene, apatite, and zircon are all fairly abundant, the two former building rather large crystals.

The syenites are represented by what I may term the Hillside intrusion, three miles from Bulawayo, which is of so much interest that I hope to describe it fully in a future paper. I may mention,

[1] See MacMahon on the gneissose-granite of the Himalayas, GEOL. MAG., 1897, pp. 345–355.

[2] "The Copper-bearing Rocks of South Australia": Brit. Assoc., 1901.

however, that the most abundant variety is an even-grained rock of typically granitic structure, but entirely destitute of quartz. The felspar is almost exclusively microcline, while hornblende and augite are about equally abundant. Sphene occurs in very perfect yellowish crystals, while apatite, zircon, and magnetite are also present. An augite-diorite occurs as a basic modification of the mass, but more typical diorites occur as segregations from the Matopo granite near Bulawayo. In these hornblende is the ferro-magnesian constituent, while microcline, oligoclase, and orthoclase are present as in the granite itself. Apatite and sphene are very abundant, and often form large though somewhat irregular crystals. There are also a few granules of magnetite.

Fig. 4.

Numerous intrusions or segregations of gabbro occur in the very interesting plutonic complex round the Umniati River in Mashonaland. One example from the Goedyema Road, north of the Sarui River, is a beautifully fresh rock made up entirely of augite and felspar. The structure is typically granitic and the grain coarse and even. There is not a single grain of magnetite present, and the rock is consequently remarkably light-coloured for so basic a variety. Most of the augite shows diallagic striation and schillerization, due to the presence of two sets of rather large, regularly arranged inclusions. The felspar is evidently near anorthite, giving symmetrical extinctions up to 37°. Specimens from three other localities in the same district have characteristics which seem to be due to the influence of the rocks into which they were intruded. In one from the Sarui River, enstatite is the most abundant ferro-magnesian constituent. It occurs in elongated crystals of considerable size and is partially altered to serpentine. Augite is also common, and often shows good cleavage and a basal striation. This, combined with twinning on the orthopinacoid, gives rise to good examples of the 'herring-bone' structure. Repeated twinning is also well shown, one large crystal being divided into six equal-sized lamellæ. The felspar is allotriomorphic. It forms large grains which exhibit Carlsbad, albite, and pericline lamellation. The extinction angle rises to at least 30°. Small flakes of biotite and granules of ilmenite are present. A little quartz also occurs, chiefly as micropegmatite. A specimen from the Gwelo-Selukwe Road shows more abundant biotite in small, very pleochroic flakes. The dominant ferro-magnesian mineral is, however, augite, in which the herring-bone structure is almost always shown. A little enstatite and hornblende are present, the latter sometimes bordering the augite. The plagioclase evidently approaches anorthite in composition, and forms larger grains than the other constituents. Ilmenite sometimes builds good-sized irregular granules, while quartz, chiefly in micrographic intergrowth with felspar, is sparingly distributed. A specimen from another locality is remarkable for the abundance of strikingly pleochroic yellowish biotite, so that it may be described as a biotite gabbro. Hornblende is also present and sometimes borders the augite. In other respects the rock is similar to the two previous varieties.

Though somewhat rare, as in other parts of the world, ultrabasic rocks are widely distributed in South Africa. They have, indeed, received more attention from European geologists than any of the other divisions. The breccia and eclogite of Kimberley and of Jagersfontein in the Orange River Colony are so well known that it is needless to do more than mention them. The very interesting melilite-bearing rock from the Spiegel River in Cape Colony, described by Professor Cohen,[1] provides the only instance of the occurrence of a felspathoid, other than nepheline, in our province, though leucite basalts, etc., have been recorded from Kilimanjaro in Central Africa. Picrites have been described from the Transvaal and elsewhere by various writers, so I will confine myself to a brief mention of a rock from Porselt's Vlei on the road from Inciza to Belingwe in Southern Matabeleland. It is very coarse-grained and of a uniform dark-green colour. Olivine appears to be the sole constituent, as iron-ores are conspicuous by their absence, and there are no indications in thin section which would lead one to suspect the presence of any other ferro-magnesian mineral. The rock is beautifully fresh and quite free from even incipient serpentinization.

VI.—River Development.

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

In the Quarterly Journal of the Geological Society, May, 1902, vol. lviii, p. 207, Mr. A. Strahan has a paper on the "Origin of the River-System of South Wales, and its Connection with that of the Severn and Thames." It is with the part of the paper expressed in the latter portion of the title that I am more particularly concerned; for in that connection Mr. Strahan remarks

[1] T.M.M., 1894, p. 188. See also Ann. Rep. Cape Geol. Comm., 1898.

in a footnote (p. 219), "The theories put forward by Mr. S. S. Buckman in Proc. Cotteswold Nat. Field Club, vol. xiii (1900), p. 175, following the lead of Professor W. M. Davis, appear to me to transgress the limits of legitimate speculation." It seems rather curious that in a paper like this there is no further reference to the work done by Professor Davis, no attempt to consider his views, only a dismissal of them, implied in the rejection of the views which I have advanced in accordance with his teaching, which views, by the way, I gave in more detail in *Natural Science*, April, 1899, vol. xiv.

However, we are bound to infer from the manner of Mr. Strahan's condemnation that his own theories are within the limits of legitimate speculation. Let us see how far they bear investigation.

The author postulates an anticline of the Chalk, with a Caledonian trend, more or less coinciding with the present escarpment in direction. How far to the north-west of the present escarpment it lay he does not indicate; in this matter he is vague. Only he tells us that "The rivers rising in the low-lying [*sic*] Oolite region flow eastward against the general run of the country [*sic*] . . . . and were initiated on an eastward slope of Chalk," etc. Therefore the anticline must have been situated at least as far north-west as the line of the present Oolite escarpment. Evidence he gives in a footnote: "The existence of certain valleys breaching the [Chalk] escarpment, but not now occupied by streams is explained by Prof. Gregory on the supposition that they carried the drainage from that part of the Chalk plain which has perished." Quite so; granted, so far as to say that the breaches were made by rivers flowing off high ground beyond the Chalk escarpment—how much of it was Chalk is unimportant. But the same argument applies, with greater force, to the Cotteswolds. The breaches of the Cotteswold escarpment are even more noticeable than those of the Chalk, and, as I pointed out before I had heard of Professor Davis or his theories, these breaches must have been cut by eastward-flowing rivers,[1] an idea which also had occurred to Dr. T. S. Ellis years ago.[2] These rivers must have drained a large area to collect the necessary volume of stream[3]—that is to say, Mr. Strahan's anticline would have to be placed well to the north-west of the present Oolite escarpment. This is legitimate speculation; because Mr. Strahan can hardly complain if the same argument which is used in regard to the breaches of the Chalk escarpment is applied to those of the Oolites. But it is a *reductio ad absurdum* for Mr. Strahan's contention. The anticline which he wishes to place eastward of the Severn in order to deflect that stream must, following his own line

[1] Q.J.G.S., vol. liii, p. 626.

[2] I have given an account of all this in my above-mentioned paper in *Natural Science*.

[3] The meander curves of the Cotteswold valleys, pointed out to me by Professor Davis, form the strongest evidence here, and I am afraid Mr. Strahan does not appreciate its importance. But any theory of river development must account for these meanders; it cannot ignore such facts. They are illustrated in my two papers above mentioned.

of argument, be placed to the west of the Severn, where it would fail in its object.

Certain remarks of Mr. Strahan now call for notice. He speaks of the "low-lying Oolitic region." But the Oolitic region of the Cotteswolds is from 200 to 300 feet higher than the Chalk of the Chilterns or Berkshire Downs. He speaks of the rivers flowing against the general run of the country. But they do not—they flow with the dip. The general long slope of the country is from the Oolites to the Chalk.

Further, Mr. Strahan says, "The Chalk escarpment now forms the main water-parting through much of its range across England" (p. 219). But in his map he shows the Chalk escarpment extending from the English Channel to the Wash, about 210 miles; and yet he only shows the coincidence of water-parting and escarpment for some 40 miles. These are not matters of speculation, they are matters of fact.

In another matter of fact Mr. Strahan has erred. In his map (pl. v) he has placed the Vale of Moreton in the wrong place, on the edge of the Cotteswold escarpment. But that is a good dozen miles too far to the west. It is very convenient for his theory, but then it is wrong in fact, and wrong facts do not seem to be a satisfactory basis for legitimate speculation. As a matter of fact the Vale of Moreton is on the east of the Cotteswolds, not on the west; it is a good dozen miles to the east of the headwaters of the Thames streams. This is particularly unfortunate for Mr. Strahan's theory. He says that his anticline must have run "along the line of the water-parting. Traces of such an anticline have been detected by Mr. Buckman in the Vale of Moreton." But put the Vale of Moreton in its right place, and these two statements are flatly contradictory. The Vale of Moreton is not along the line of the water-parting, it is to the east of it. And if the anticline of the Vale of Moreton had had any appreciable influence it must have made the Cotteswold streams flow westward, not eastward.

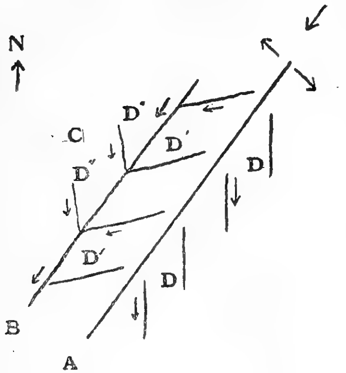
Is it legitimate to quote my evidence of the Vale of Moreton anticline in this connection? I think not. The anticline of which I speak in the paper quoted by Mr. Strahan (Q.J.G.S., 1901, vol. lvii, p. 146) is relatively a very small one, formed in Inferior Oolite times, denuded, and completely covered over again by later Inferior Oolite rocks. No doubt there is the principle "once an anticline, always an anticline": as I have pointed out (p. 147) evidence of successive movements along the same line of weakness may often be seen. I will allow Mr. Strahan to make what he can of this. He is seeking for an anticline with an axis having a Caledonian trend. The Moreton anticline has a Malvernian trend; it is a feeble continuation of the line of the Pennine range. Therefore, the Moreton anticline has not the direction Mr. Strahan requires; and, as I have shown, it is not in the position that he wants, it is not where he has marked it on his map, and it does not coincide with the water-parting.

It seems very remarkable that for an anticline such as Mr. Strahan postulates, an anticline so important as to have divided the rivers of England and to have deflected the Severn, there should be no more evidence than "traces." If there were such an anticline as Mr. Strahan supposes there must be more than traces. This Chalk anticline could not have been formed without the upheaval of the underlying Jurassic rocks. Therefore, north-west of the water-parting, that is, north-west of the Cotteswold escarpment according to the theory, the Jurassic rocks should dip differently from what they do to the south-east thereof. A very little upheaval should have put them level; a little more, enough to make an anticline sufficiently important for Mr. Strahan's purpose, should have given the Jurassic rocks a decided tilt to the north-west. But the facts are all the other way: the Jurassic rocks of the Severn-Avon valley dip persistently to the south-east; they dip just as the Oolitic rocks of the Cotteswolds do. To postulate an anticline in the face of these facts ought to require a robust imagination; and it hardly seems desirable for anyone possessed thereof to label other theories which do at any rate fit such facts as these.

Suppose, however, that spite of the dip we grant the required anticline. What happens? Mr. Strahan says, "On the west side [of the anticline] the rivers are deflected to a south-westerly course as in the case of the Avon and Severn, or to a north-easterly course as in the case of the Ouse and Nen" (p. 220). Why the Ouse and Nen, when they rise behind, that is to the east, of where the supposed anticline would have run? It sounds rather haphazard, this parting of the waters. But of course Mr. Strahan has carefully considered what this statement involves before making it. When the rivers come into the syncline, which must of necessity lie to the west of the anticline, they still obey the law of gravity as to their further course. Some flow north-east, some south-west; therefore the syncline must have dipped in these two directions from a central axis in order to produce this phenomenon. Here, then, is another anticline to be accepted, one that must have been approximately at right angles to the other, a Charnian anticline this time. Mr. Strahan does not say anything about, nor offer any evidence for, its existence; yet logically such an anticline is an absolute necessity to justify his statement.

Suppose we accept both these anticlines and see what the position would be. We have a Caledonian anticline with a syncline to the north-west of it; this syncline dipping south-west and north-east from a Charnian anticline. The Caledonian anticline must have been similarly affected. Let us consider the Severn-Avon part. We have on the south-east of these rivers an anticline running approximately from north-east to south-west, and its axis dipping south-west, according to the necessities of Mr. Strahan's hypothesis. What happens? Observations on any good road which runs downhill will tell us. The crown of the road is the anticlinal axis, dipping downhill; the gutter between the road and the path is the syncline, dipping similarly. From the crown of the road and from the path the water cuts channels to the gutter, not at right angles, as it would if the axis were level, but in a direction intermediate between the dip of the longitudinal axis and the dip from the crown to the gutter (Fig. 1).

The same thing is shown even better in a courtyard as regards synclinic drainage. I have in mind the Close at Gloucester, where there is a dipping syncline such as B, with oblique lateral channels like D′, D″. These artificial cases would have shown Mr. Strahan that his river drainage should be on the same plan. But he could have verified them by actual examples of river drainage; as regards the anticline, how off the north side of the Mendip axis, which runs approximately west to east with east dip, the streams flow north-eastward,[1] or how off the east side of the Pennine axis the streams like the Swale, Ure, Nidd, Wharfe, and Aire drain approximately south-eastward. Or, as regards a syncline, how, in that to the north of the Pewsey axis, the streams from north and south run obliquely to meet in the synclinal trough of the Kennet-Thames.



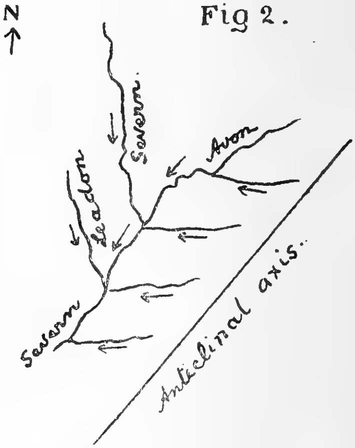


Fig. 1.—Drainage of a road and path. A, the crown of the road—the anticlinal axis, dipping south-east; B, the syncline—the gutter between the road A and the path C; D, D′, streams draining off the dipping axis at oblique angles; D′, D″, streams obliquely joining the synclinal or trough stream of the gutter.

Fig. 2.—Direction of tributaries on the left bank of Severn-Avon, to fulfil Mr. Strahan's hypothesis.

Examples of drainage show conclusively, then, that Mr. Strahan's river-system should have been after the manner depicted in Fig. 2; the tributaries draining his supposed anticline should have flowed obliquely. But the facts are against him: the tributaries on the left bank of the Severn-Avon have not the direction which his hypothesis requires; but they flow in a peculiar manner, more or less against the direction of the Severn and Avon (Fig. 3).

Now these tributaries diverge more or less from a central point;

[1] S. S. Buckman, "Excursion to Dundry": Proc. Geol. Assoc., 1901, vol. xviii, pt. 4, p. 157, fig. 9.

they diverge towards the main stream instead of converging. There are two explanations of such divergence, one where streams rise from a central domelike elevation and flow off in a radial manner; such, I presume, is the drainage of Dartmoor. But there is no evidence for any domelike elevation in the north-west Cotteswolds, and moreover the other rivers of the district do not accord therewith. That explanation cannot be right here. The other explanation may be tried, it is more elaborate. It is that these tributaries of the Severn-Avon have worked back in and now occupy valleys which were originally marked out by streams that flowed in the opposite direction, namely, with the dip, before the Severn valley had been made, and these streams converged to join the Thames river-system.

This theory, says Mr. Strahan, transgresses the limits of legitimate speculation. At any rate, however, it has the merit of agreeing with facts, such as those of the dip, of the breaches in escarpments, of the river distribution; and it gives a logical explanation of river phenomena. It supposes an original river-system flowing off the Palæozoic rocks of Wales on to the Secondary rocks of England, cutting channels in Oolites and Chalk on its way to the sea. An analogous condition of affairs in the case of the river-system of the east side of the Pennine range can be pointed to.

Fig 3.

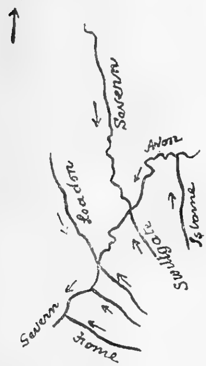


Fig 4

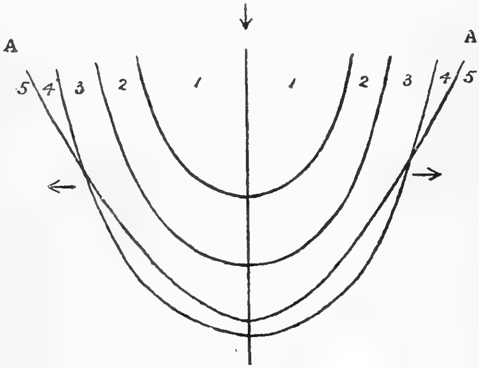


Fig. 3.—Actual directions of tributaries on left bank of Severn-Avon.

Fig. 4.—A south-dipping Malvernian anticlinal axis—outcrop of beds 1–4 after denudation. A, A, line of outcrop of covering bed 5 after a second uplift and denudation.

The main features of the theory, rivers flowing with the dip, the effect of differential denudation, river growth and river capture, had occurred more or less independently to various observers. To Professor Davis belongs the great merit of bringing the ideas as it were to a focus, giving them practical application, working out a definite theory, and especially pointing out the evidence for river capture. Following his lead again, I may now give the theory application to the district under discussion, and a little elaboration at the same time. The theory postulates for its main features two well-known anticlinal systems, the backbone of Wales, with approximately north-south direction, dipping south towards the syncline connected with the South Wales Coalfield, and the South Wales-Mendip-Pewsey-Wealden anticline, with approximately west to east direction, dipping east. Minor anticlines may be disregarded for the present.

When an anticline of Malvernian direction dips south and is denuded the lines of outcrop converge southwards (Fig. 4, 1–4). If this denuded anticline be covered by a later deposit, be again uplifted, and denuded, the line of outcrop of the later deposit will diverge more from south to north than those of the earlier deposits (Fig. 4, A, A). The same laws will apply to an Armorican axis dipping east—turn the apex of Fig. 4 to the right hand. When one anticline is crossed by another denudation will give circular to ellipsoidal lines of outcrop, the latter shown almost perfectly in the structure of the Weald.

Fig 5.

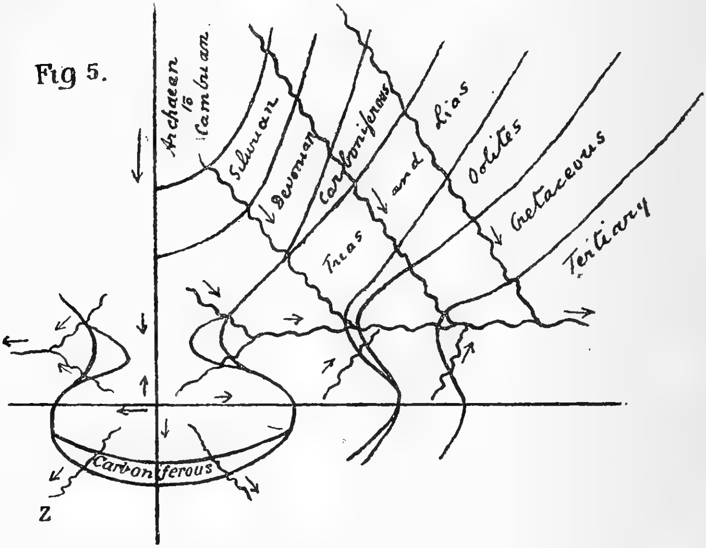


FIG. 5.—Combination of south-dipping Malvernian axis and east-dipping Armorican axis, showing the rock outcrop which would be produced and the dip streams which would be initiated. The wavy lines represent the streams. Z, the stream which developed to become the Severn. (Anticlinal axis not necessarily equal-sided.)

Here I may remark that a good example of a system of anticlines crossing one another at right angles, and also of curving anticlines on account of lateral thrust, is shown in the mosaic floor of the central hall of the Natural History Museum, South Kensington.

Taking the two anticlines of Malvernian and Armorican directions, with their respective south and east dips, combining them according to the principles laid down, allowing for three main overlaps—

post-Carboniferous, post-Jurassic, post-Cretaceous—we obtain a rock-structure with lines of outcrop arranged as in Fig. 5. Then, if we fill in the names of the various rocks, we shall see that it gives us what may be called the fundamental plan of the geological structure of Mid-Wales, Mid-England. In a generalized way it accords with the geological map; its discrepancies therefrom are no more than the omission of minor local anticlines would account for, together, of course, with local curvature of anticlines.

One point before proceeding further. Apparently Caledonian and Charnian directions of strikes and folds are not strictly due to impulse at right angles to the respective directions, that is, from north-west or north-east, but they are the immediate result of a combination of the north and south with the east and west lines of foldings which are dominant in the Eastern Hemisphere. With a Malvernian axis dipping south, Caledonian direction is given to the outcrop of beds on the east, Charnian to those on the west. With an Armorican axis dipping east, Charnian direction is given to the strata on the north, Caledonian direction to the strata on the south.

We have already seen that, from a dipping anticlinal axis, streams run in an oblique direction. Therefore, from the east of the south-dipping Welsh backbone the streams would first run obliquely—that is, in a south-east direction—at right angles to the Caledonian strike. From the north of the east-dipping Mendip-Pewsey axis the streams would run north-eastwards at right angles to the Charnian strike. In all cases the less the axial dip the less the oblique direction. Then these two series of dip streams would meet together in the synclinal trough north of the Mendip-Pewsey axis, in the line of the Kennet-Thames: that is a trough stream. Such is the initial stage of river development.

The second stage commences when the covering rock, whatever it may be, has been stripped off enough to expose the outcrops of older rocks; then differential denudation begins; the soft rocks are denuded faster than the hard ones, so that the latter are left to form escarpments. Strike streams are started along the outcrops of soft rocks; the growth of strike streams results in river capture. There is no better illustration of that than the manner in which the dip streams of the Cotteswolds are caught by the strike stream which has developed along the line of soft rocks in the Vale of White Horse.

The third stage follows on the capture process—rivers working back against the dip are started in the valleys of the beheaded dip streams. They necessarily follow up those valleys because those valleys are the lowest ground, made so by the original dip streams. So the phenomenon of breached escarpments with the water-parting in the low ground of the valley and streams flowing in opposite directions from that parting is seen to be exactly the result of the course of events here detailed.

What is to a certain extent abnormal, so far as the Severn is concerned, is the fact of its being an invader in what is strictly

Thames territory. It has come from west of the line of the Welsh backbone, and has broken into the Thames district. A stream such as that marked Z in Fig. 5 would have eaten its way back through the anticlines bounding the Thames Basin, because of its ability to give a quicker fall in a shorter distance; when it got past the anticlinal axis and into the soft Trias-Lias territory its course would have been easy. On the phenomenon of river-robbery in connection with an anticlinal axis I have given some details in the paper condemned by Mr. Strahan, dealing with the Salisbury Avon and the Pewsey anticline (Proc. Cotteswold Club, 1900, vol. xiii, p. 186). I have there shown that above-ground robbery is not the sole method of conquest; underground robbery is an important feature, preparing the way for the former.

One recommendation of the theory which I have very shortly epitomized is that its principles are applicable to all river-systems; whereas Mr. Strahan's hypothesis would only account for an isolated case. He could not bring in an anticline to account for every strike stream, nor for every case where the water-parting happened to coincide with the escarpment. So he would have to bring forward other hypotheses; and to have to account for similar phenomena by different hypotheses always seems rather dubious.

The river-system of the Paris Basin, for instance, can, in the light of the theories of Professor Davis, be read just as easily as that of the Thames. There are the dip streams, such as the Seine and its neighbours, draining from Palæozoic rocks across the outcrops of the Secondary strata into the Tertiary Basin. Then there is an invader from the outside comparable to the Severn, namely, the Loire, which has broken through the Palæozoic rocks in the west, has found its way into the Seine area, and has, at Orleans, captured the Upper Loire, which was evidently once a river of the Paris Basin system.

And now, leaving it to be judged whose theories transgress the limits of legitimate speculation, perhaps I may be allowed in conclusion to pen a few axioms of river development which do not seem to be rightly understood.

Differential denudation has so altered the face of the country that what appears now as an easy course for a river would have been impossible when the river started.

Escarpments are produced by the removal of material. This is self-evident; but the logical consequences do not seem to be appreciated—that the escarpments were not in existence when the rivers were initiated, and therefore they would not have formed any barrier to the river course, much less the formidable barriers which they now seem.

Streams which run down a slope or along a sloping trough, that is, dip streams and trough streams, are the only two kinds of rivers that are produced *ab initio*. Strike streams and anti-dip streams cannot be produced by water running off the original slope; they are only produced on the secondary slope which results from river erosion, and they have to grow by eating backwards.

Therefore, the Thames cannot be given a strike course into the

Wash, as was suggested, I think, by Prestwich; that would be equivalent to expecting a river to run along the level instead of down the slope; nor could the Upper Severn be given an original course into the Dee, suggested by Professor Lapworth, that would be almost equivalent to asking it to run uphill.

Rivers may abandon the hard course for the easier one, but not the easy one for the difficult. If the Thames had originally gained the sea by the Wash, and the Upper Severn got to the Dee, some particular damming-up theory has to be put forward to account for their leaving these easy courses to cut through the Chalk or Silurian barriers respectively. That is to say, abnormal conditions have to be postulated to explain a common and normal phenomenon. And when these conditions are applied to other cases they fail. Applied to the Weald they would mean that the drainage originally escaped *viâ* Hastings, then that this outlet was blocked in such a peculiar manner as to cause the drainage to cut several separate and independent channels through the Chalk to the north and south of the Weald!

VII.—Origin of the Crystalline Limestones of Ceylon.

By A. K. Coomáraswámy, B.Sc., F.L.S., F.G.S.

It is generally supposed that the crystalline limestones which occur amongst the schists, associated with orthogneisses, in various parts of the world, are altered sedimentary limestones whose accessory minerals and crystalline structure have been developed by simple contact and dynamo-metamorphism; and no doubt many crystalline limestones are of sedimentary origin, and owe their peculiarities to these agencies. In other cases the peculiar mode of occurrence of such rocks or their manner of association with igneous rocks (orthogneisses or nepheline-syenites) has led to the suggestion of other theories.

Professor Högbom [1] has described the crystalline limestone which is associated with the elæolite-syenite of Alnö, where all transitions occur from pure limestone to calciferous and normal elæolite-syenite. Intergrowths of calcite with nepheline, ægirine, and felspar were noted. Professor Högbom (p. 109) thinks that, whatever the origin of the limestone (it seems not likely to be an altered sedimentary one), it is quite certain that it has been melted and taken up by the magma on a large scale without decomposition, and that on consolidation, calcite has crystallized out of the magma in just the same way as the other minerals.

Professor Judd [2] has suggested that the crystalline limestones of Burmah (which in many respects very closely resemble those of Ceylon) result from the alteration of the basic lime-silicates of the pyroxene-gneisses. My observations show that this is a theory not applicable to the crystalline limestones of Ceylon. This is shown by the field relations and by the fact that the Ceylon granulites are

[1] Geol. Fören. Stockholm. Förh., 1895, vol. xvii, pp. 100 and 214.
[2] Phil. Trans. Roy. Soc., 1896, vol. clxxxvii A, pp. 151–228.

almost always exceedingly fresh. The calcite and lime-silicates found near the junctions are not the result of alteration of minerals composing the granulites. Contact-metamorphic relations between the limestones and granulites are everywhere indicated.

Dr. Callaway has suggested that the crystalline limestones of Bodwrog and Porth Trecastell in Anglesey,[1] and of Ceylon,[2] may have originated by "segregation from plutonic rocks during deformation." That the Ceylon limestones have not been formed thus is shown by the contact-metamorphic relations between them and the granulites, and the freedom from deformation of the latter, with which they are inseparably associated.

Mr. Holland[3] has suggested that the crystalline limestones of Burmah may have existed in a state akin to fusion. Calcite has been claimed as an original mineral in nepheline-syenite by more than one observer.[4] The present writer has described what is probably an original intergrowth of calcite with quartz.[5]

I have recently given some account of the crystalline limestones of Ceylon,[6] showing that a vast series of granulites, various in chemical and mineralogical composition, is there most intimately associated with a smaller but widely distributed series of crystalline limestones occurring in bands of various widths, whose foliation (dependent on variations in coarseness of grain, structure, and mineral composition) is parallel to that of the granulites and to the boundaries between the two rocks. The contact phenomena and the transitions between the two types of rock are also described.

As to the real *origin* of these limestones, not very much can be said. We might regard them as altered sedimentary or even tufaceous rocks, which the intrusive granulite has melted and partially absorbed. The wollastonite-scapolite gneisses of Galle might, on this supposition, result from the total absorption of a large mass of limestone by the granulites. It may be objected, however, that there is little or no evidence of the existence of other altered sedimentary rocks such as would probably have accompanied the limestone,[7] and that the limestones occur in different areas, sometimes abundantly and in wide bands, sometimes in narrow bands far removed from other rocks of the same sort.

[1] Rep. Brit. Assoc., 1887, p. 706.

[2] Geol. Mag., 1902, p. 285.

[3] Mem. Geol. Surv. India, 1901, vol. xxx, pt. 3, p. 175.

[4] Holland: Mem. Geol. Surv. India, loc. cit., p. 197. Adams: Amer. Journ. Sci., 1894, vol. xlviii, p. 14.

[5] Quart. Journ. Geol. Soc., 1900, vol. lvi, p. 606, also pl. xxxiii, fig. 1.

[6] Quart. Journ. Geol. Soc., 1902, vol. lviii, p. 399.

[7] I have met with rocks almost composed of dark mica in one or two localities (Yatirawana, near Wattegama, and Talbot Town, Galle) associated with the granulites. Almost any mineral occurring in the granulites may, however, be sometimes met with in this way as a main constituent of a local variety. It is, however, quite true that some varieties rich in garnet and biotite are not altogether unlike much altered sedimentary rocks, though I do not myself regard them as such. Lacroix has described some rocks in which andalusite, sillimanite, and corundum occur, but unfortunately the localities in Ceylon are unknown. Possibly these minerals indicate the existence of altered sedimentary rocks, but this is by no means necessarily the case.

Whatever their original character may have been, the limestones must have existed before the intrusion of the granulites. I think it is clear, however, that *in their present condition* the two rocks are 'contemporaneous,' and this is shown by their intimate associations and similar behaviour, and by the transitions from one rock to the other which sometimes occur. I suggest that the limestones themselves have existed in a state akin to fusion [1] and have behaved much as igneous rocks, and that the carbonates entering into the constitution of the granulites near the contacts are, as they appear to be, original minerals.[2] That the limestones have existed in a state akin to fusion is shown, I think, by the appearances of flow-structure (foliation),[3] the occasional porphyritic structure, the aggregates of accessory minerals (which correspond perhaps to the basic secretions of some igneous rocks), the intergrowths of calcite and dolomite, and by the field relations of the limestones and charnockite series. The accessory minerals have crystallized out as if from a magma. The limestones may have been softened before the intrusion of the granulites (which greatly exceed them in amount), or have become so as a result thereof. Each rock has been affected near the contact by the absorption of material from the other, the granulites showing the more conspicuous modifications. This transference of material is shown in the granulites near the junctions by the appearance of minerals rich in lime, such as scapolite, sphene, diopside, phlogopite, and calcite, and in the limestones by the appearance of minerals such as diopside, amphibole, phlogopite, and spinel, and very rarely scapolite and felspar. The common occurrence of spinel as a contact mineral seems to result from the appropriation of all available silica in the formation of lime-silicate minerals, leaving the oxides to form spinel.

The whole process must have taken place under conditions of great pressure. Differential movements during consolidation have produced the conspicuous foliation. To some extent the limestones and granulites have been rolled out together during consolidation, and in this way sills of granulitic rock in the limestone have been broken and portions separated, sometimes as lenticles continuing along the strike the unbroken portions of the sill, sometimes to form irregular patches or snaky twists of pyroxenic rock in the limestone, sometimes to be found as quite isolated masses, surrounded by the enclosing limestone.

To summarize, I wish to suggest—

(1) That contact-metamorphic relations between the limestones and the charnockite series are everywhere clearly indicated.

[1] The direct use of the term 'molten' is avoided, inasmuch as we can know but little of the conditions of matter under very great pressure, and it is inadvisable to use the same terms in the description of conditions which, though analogous, must yet be very different.

[2] Cf. J. J. H. Teall, Geol. Mag., 1886, p. 349.

[3] It is evident that the limestones have not (except very locally) suffered from deforming earth-movements since the development of the accessory minerals, whose varying abundance is largely the cause of the apparent foliation.

(2) That it is not altogether easy to regard the limestones as altered sediments.

(3) That whatever their origin they have actually existed in a state "akin to fusion," and as far as their present characters are concerned, are contemporaneous with the charnockite series.

(4) That limestones and the charnockite series have suffered but little from deforming earth-movements since their final solidification.

NOTICES OF MEMOIRS, ETC.

1. The International Geological Congress.—The next Session of this Congress will be held in Vienna from the 20th to 27th August, 1903. The Austrian geologists have appointed a committee of organization, which has just issued its first circular. The President is Dr. E. Tietze; the general secretary, Professor C. Diener; and the secretaries, Messrs. F. Teller, G. Geyer, and A. von Böhm. The circular contains a list of the excursions which it is proposed to arrange in connection with the Congress. The following are to take place before the Session:—1. Palæozoic region of Central Bohemia. 2. Hot Springs and eruptive districts in the north of Bohemia; and the surroundings of Brünn in Moravia. 3. Galicia, beginning with the coal district of Ostrau and the neighbourhood of Krakau and Wieliczka, then dividing into two sections, one of which visits the petroleum beds, and the other the peaks of the Carpathians and the Tatra Mountain. 4. Salzkammergut. 5. Styria. The following are to be after the Session:—6. Dolomites of the Tyrol. 7. Basin of the Adige in Tyrol. 8. Western region of the Hohe Tauern (Zillerthal Alps). 9. Central region of Hohe Tauern (Venetian Alps). 10. Predazzo. 11. The Carniolan and Julian Alps. 12. Glacial region of the Austrian Alps. 13. Bosnia and Dalmatia. There is also an invitation from the Geological Society of Hungary, which includes a visit to Buda-Pesth and the lower course of the Danube (Cataracts and Iron Gate).

2. Illustrations of Volcanic Phenomena.—There has been arranged at the British Museum a temporary exhibition to illustrate the recent volcanic eruptions in the West Indies, and their phenomena. Within about a fortnight of the eruptions in St. Vincent and Martinique, the Exhibition was installed in that gallery of the Geological Department in which other collections elucidating the dynamic side of geology are already displayed. Now, however, it is placed in one of the bays of the central hall, where it has attracted a large number of visitors. A general guide-label informs the visitor that the Exhibition is arranged in several sections which should be examined in regular order, as follows:—

A series of maps and diagrams, some specially prepared, shows the geography of the Lesser Antilles and the relations of their volcanoes to the general structure of the globe, particularly to the disturbed region of Central America. On these maps, pins have been inserted drawing attention to places specially affected during the last few months. Adjoining this are pictures and photographs of the scenery, buildings, vegetation, and human inhabitants of the ruined islands. A noteworthy contribution to this section is the excellent series of sketches lent by the Rev. W. C. Bourchier, R.N. The recent elevation of the Antillean Ridge from great depths is illustrated by specimens of fossil animals and their recent congeners, specially selected for that purpose. Next follow specimens illustrating the volcanic geology of the Lesser Antilles, the dust from this and previous eruptions being, of course, exhibited and explained. We understand that arrangements have been made to acquire further specimens of volcanic ejectamenta from Martinique and St. Vincent. The next section illustrates the fauna and flora of the Lesser Antilles, attention being specially directed to such species as are exceedingly rare (possibly owing to the effects of previous catastrophes) and whose extermination is feared, also to species characteristic of the islands and, as such, mentioned in the accounts of travellers. The portion of the Exhibition having special reference to the Lesser Antilles is concluded by a series of extracts from local newspapers and other notes having reference to present and previous eruptions in that region. The remainder of the Exhibition deals with volcanic phenomena generally: first, by means of a large series of plates and photographs ranging from the sixteenth century to the present year, and representing many of the best known volcanoes of the globe, as well as some of the extinct or possibly dormant volcanoes in various parts of the world; secondly, by a typical series of volcanic products, carefully labelled for the benefit of the public. Dr. Bather and Mr. Prior are responsible for this exhibition.

3. Natural Science Records.—The Geological Record, the Annuaire Géologique, the Annals of British Geology, not to mention less ambitious attempts, having had their day and ceased to be, and the Record of Geological Literature added to the Geological Society's Library having entered on a period of æstivation, it may be of service to indicate yet another bibliography, the "Revue Bibliographique des Sciences naturelles pures et appliquées . . . publiée par J. Chavanon et G. Saint-Yves. . . . Paris, 45, Avenue Ledru-Rollin."

The *Revue* is announced to appear in monthly parts of five or six octavo sheets, at a subscription price of 30 francs for addresses in the Postal Union.

The programme is far too large to be filled with any success in an annual volume of such restricted size; but by devoting special attention to Agronomic Science the promoters will fill a gap. We cannot say the same for the second feature on which they pride themselves, namely, the indexing all names of new genera and species, or species from new localities, since this is already performed by the Zoological Record and by the Concilium Bibliographicum, Zurich, which two bibliographies supplement each other's inevitable deficiencies. Under each of the main headings—Geology, Mineralogy and Mining, Zoology, Anatomy, and so forth—is given an annotated list of the contents of certain parts of a number of periodicals, taken by countries. Each number is completed by an index to the subject-matter and a list of the periodicals noticed in that part. This latter is a useful feature.

4. Dr. F. A. Bather, M.A.—On April 23 the Principal Trustees of the British Museum appointed Dr. F. A. Bather to fill the Assistant-Keepership of the Department of Geology, rendered vacant by the promotion of Dr. A. Smith Woodward to the Keepership on the 18th December previous.

5. Earthquakes in Greece.—It may not be generally known that there is published a list of earthquakes observed in Greece for the year. The list appears in *Annales de l'Observatoire Nationale d'Athènes*, edited by Professor Démétrius Eginitis. Volume iii, 1901 (4to, *Athènes*), contains the earthquakes recorded for the year 1899, in chronological orders. In each case the time is given, its strength noted, direction, length, and the name of the recorder. The utility of this valuable record would be much enhanced if Professor Eginitis would give an alphabetical index to the localities in future lists.

6. Emendations of Ammonite Nomenclature.—Under the above title, Mr. S. S. Buckman has issued an 8 pp. pamphlet of revision of the nomenclature in his monograph on the Inferior Oolite Ammonites published by the Palæontographical Society. The pamphlet, at first issued privately in June, has now (July) been published, and is on sale at Norman, Sawyer, & Co., Cheltenham, price one shilling. It contains numerous new generic and trivial names.

REVIEWS.

Aids in Practical Geology. By Professor Grenville A. J. Cole, M.R.I.A., F.G.S. 4th edition. 8vo; pp. 431. (London: Charles Griffin & Co., 1902.)

We were able to speak highly of this "eminently practical" work on geology eleven years ago in our notice of the first edition (Geol. Mag. for 1891, p. 230). We therefore welcome the fourth edition, for it proves that the labours of the author have been appreciated. Those of our readers who have not yet acquired the book should know that it does not deal with economic geology, but is intended as a companion to ordinary textbooks, and to give instruction to the student in the methods of examining and determining minerals, rocks, and fossils. The work has been revised throughout, and amongst the fresh information mention should be made of that on the isolation of the constituents of rocks. The author observes that "Few changes in nomenclature have been introduced into this edition, and the limits of the names of rocks, and even of fossil genera, have been kept as wide as possible." This is right. Nomenclature is the bane of students and of teachers of natural science, in respect of its 'kaleidoscopic' changes; and Professor Cole has not been able to escape them altogether.

We cannot think he has acted wisely in substituting De Lapparent's 'Gotlandian' for Upper Silurian. The student should be taught to use the generally accepted terms. Silurian drops out entirely from Professor Cole's Table of Formations (p. 293).

REPORTS AND PROCEEDINGS.

Geological Society of London.

June 11th, 1902.—Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair.

Professor Bonney exhibited a mounted specimen of the volcanic dust which fell on the deck of the steamer *Roddam* during the great eruption of Mont Pelée on May 8th, for which, as well as for another from the Soufrière of St. Vincent, that had fallen in Barbados, he was indebted to Sir William Crookes, F.R.S. The dust from Mont Pelée consists of fragments of minerals and rock (the former, perhaps, slightly in excess of the latter), very commonly about ·007 to ·008 inch in diameter, but ranging from about ·005 to ·01 inch. A very little fine dust had been removed by levigation before mounting the specimen. The minerals are:—(1) Chips of felspar sometimes bounded by cleavage-edges, occasionally showing oscillatory twinning or zonal structure. The refractive index and extinction-angles suggest that the majority are labradorite. Some contain minute acicular microliths or small brownish enclosures (? vitreous), which now and then are regular in form and arrangement, like negative crystals, and not seldom contain little bubbles. (2) Pyroxene, occasionally with cleavage-edges, or even idiomorphic, generally of a light bottle-green tint. There are certainly two species: one showing a distinct pleochroism from green to brown with straight extinction—a variety of hypersthene; the other barely pleochroic, with an extinction that proves it to be augite. He could not identify with certainty magnetite or any other mineral. The rock-fragments are chips of a brownish, often dirty-looking glass, with small cavities, sometimes showing microliths or adhering to minerals; much of it opaque, or nearly so, with transmitted light, and a brownish-grey by reflected light, once or twice reddish. As Dr. Flett gave an excellent description of the Barbados dust from the Soufrière at the previous meeting, the present speaker thought that he need say no more than that in the specimen now exhibited the fragments seem a shade smaller, and minerals are slightly more abundant, especially pyroxene, than in the Mont Pelée dust.

Notwithstanding the risk of generalizing from a single slide, Professor Bonney inferred that the ejecta of the two volcanoes are generally similar. Both, compared with specimens in his cabinet from Cotopaxi, are more uniform in size. The travelled dust from the Soufrière is a little smaller than that from the actual summit of the Andean volcano, but coarser than similar material from Chillo (over 20 miles), Quito (35 miles), Ambato (45 miles), Riobamba (65 miles), and the summit of Chimborazo, about the same.

All these vary much more in size and run distinctly smaller, especially the last.[1] That from Mattakava, Hick's Bay, New Zealand (fallen on June 16th, 1886), is rather coarser, more scoriaceous, with fewer mineral fragments (especially of pyroxene), to which a dirty glass is often adherent. The dust from Barbados, ejected by the St. Vincent Soufrière in 1812, is very much finer-grained, but contains the same minerals, though pyroxene is less abundant. In neither had he found the clear glassy pumice described by Miss Raisin [2] from the marls of that island.

The following communications were read :—

1. "A Descriptive Outline of the Plutonic Complex of Central Anglesey." By Charles Callaway, D.Sc., M.A., F.G.S.

The central complex of Anglesey was originally composed of diorite, felsite, and granite. The gneiss and granitoid rock of the area, formerly regarded as sedimentary in origin, are now known to be plutonic masses. The diorite undergoes numerous modifications, into hornblende-gneiss, chlorite-gneiss, micaceo-chloritic gneiss, and kersantite and biotite-gneiss. The felsite has not been found in its original state, but is converted into 'hälleflinta,' quartz-schist, mica-schist, and mica-gneiss ; granite and quartz felsite are intrusive into the diorite and felsite, and the two former are regarded as derived from the same magma. They are not foliated, and were intruded subsequently to the modification of the diorite and felsite into gneisses and schists. The diorite, originally a zenolith surrounded and injected by granite, has been modified into an elliptical dome of dark gneiss; into simple gneisses by pressure, and into complex gneisses by pressure *plus* granitic intrusion. This intrusion has often produced fusion at the contact, sometimes with the generation of biotite in the diorite. In addition to this, the diorite possesses an imperfect fluxion-structure.

2. "Alpine Valleys in relation to Glaciers." By Professor T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

The author discusses some hypotheses about the formation of Alpine valleys which have been advanced by Professor W. M. Davis, but has left the Ticino Valley, on which the latter lays much stress, to Professor Garwood, who has very lately visited it. Professor Davis maintains that the upper and wider parts of Alpine valleys were excavated in pre-Glacial times, the lower and narrower portions during the Great Ice Age. The author tests this hypothesis by applying it first to the valley of the Visp, of the eastern arm of which, and of the 'hanging valley' like a gigantic corrie, where Saas Fee is situated, he gives a description, pointing out that all parts are so connected that any separate explanation of their form is impossible.

To obtain an idea of the condition of the Alps in Middle and Later Tertiary times, we may consider the effect of alterations of temperature, on the assumption (which, as he shows, is not likely to

[1] All these (collected by Mr. E. Whymper) are described in Proc. Roy. Soc., vol. xxxvii (1884), pp. 114 et seqq.

[2] Quart. Journ. Geol. Soc., vol. xlviii (1892), pp. 181, etc.

be seriously incorrect) that the altitude of the Alps during the greater part of their existence has remained unchanged. A rise of temperature of from 6° to 7° Fahr. would have the same effect as lowering the district by 2,000 feet; a rise of 10° would correspond with 3,000 feet. In the latter case the Pennine chain about the headwaters of the Visp would be comparable with the range from Monte Leone to the Ofenhorn. With a rise of 14° glaciers would almost vanish from the Alps, for the snow-line would then be at 12,000 feet above sea-level. Thus glacial action in the Oligocene and Miocene ages would be a negligible quantity, and it would gradually become sensible during the Pliocene; but glaciers would not invade valleys now free from them until the temperature was some degrees lower than it is at present—in other words, can have only occupied these during a small portion of their existence.

The author passes in review a number of other Alpine valleys, which lead to the same conclusion. He calls attention once more to the connection of cirques with valleys, to the impossibility of referring the former to glacial action, and to the unity exhibited by all parts of the Alpine valleys, touching upon some structural difficulties which Professor Davis has been content to meet with hypotheses. Alpine valleys in all parts, as the author shows, indicate by their forms meteoric agencies other than glaciers, which can only have acted for a comparatively short time and have produced little more than superficial effects.

3. "The Origin of some 'Hanging Valleys' in the Alps and Himalaya." By Prof. Edmund Johnstone Garwood, M.A., F.G.S.

Lateral valleys which enter the main valley marked by discordant grades in the Jongri district of the Sikhim Himalaya have been attributed by the author to Pleistocene elevation and super-erosion of the main valley by water. Similar valleys in the Val Ticino have recently been attributed to overdeepening of the main valley by ice. The author shows that there is no real proof of this; in fact, the evidence seems strongly to point to fluviatile and not glacial erosion of the main valley. This is shown by the overlapping profiles and river-gorges situated both above and below some of these 'hanging valleys,' and by the fact that a greater relative amount of erosion has taken place towards the upper end of the main valley than at the lower, where the mouths of the 'hanging valleys' are less elevated. The overdeepening of the main valley is attributed to an epeirogenic uplift in Pleistocene times, consequent on the melting away of the ice-cap, the lateral valleys being merely tilted sideways. This effect is intensified by the protection accorded to the high lateral valleys by ice, which even nowadays still lingers there. Examples from the Maloja district of the Engadine are cited as confirmatory of this. The best preserved of these 'hanging valleys' in three districts examined by the author all face north-eastward, and show protection by ice; others not so protected have begun to cut back their gorges to an accordant grade with the main valley. Examples of other types of 'hanging valleys' not due to the overdeepening of the main valley are given, and proofs of the greater power of water to excavate over ice are assigned.

CORRESPONDENCE.

BALA LAKE AND THE RIVER SYSTEM OF NORTH WALES.

SIR,—In the July number of the GEOLOGICAL MAGAZINE, Mr. Lake refers to my criticism on his paper on Bala Lake and the River System of North Wales (Quart. Journ. Geol. Soc., vol. lvi, p. 231). I take this opportunity of stating that one part of that criticism was based on a misapprehension. I understood from hearing the paper read that Mr. Lake considered that great earth-movements had taken place since the deposition of the glacial drift. On reading the paper in the GEOLOGICAL MAGAZINE, I see that I was mistaken, and I wish to assure Mr. Lake of my regret at having misunderstood his views on this point.

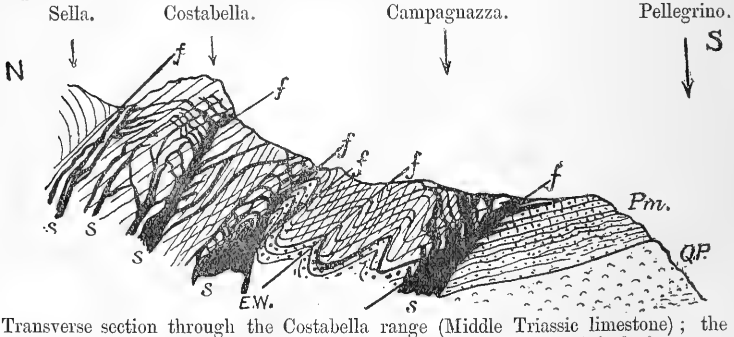
I am obliged to Mr. White for pointing out an inaccurately worded allusion to the Vale of Pewsey. The river, as he states, rises on Cretaceous and not on Oolitic rocks. My point, however, was to show that this and certain other rivers flow eastward, or join the eastward flowing system, against the general run of the country. Locally no doubt the direction of the drainage was affected by folds as suggested by Mr. White. A. STRAHAN.

SWANSEA, *July* 14, 1902.

GEOLOGICAL SOCIETY OF LONDON: LAKE v. STRAHAN.

SIR,—I think the ventilation of this matter highly desirable. Mr. Lake has, however, made one mistake in his letter. In his last sentence he surely means "Referee system of the Geological Society," and not "Burlington House." C. DAVIES SHERBORN.

ADDENDUM.—In Mrs. M. M. Ogilvie Gordon's paper "On Monzoni and Upper Fassa," which appeared in the July number of this Magazine, the four names of places *marked by arrows* above the transverse section given on p. 310 were accidentally omitted by us, which we greatly regret. The section with the names inserted is repeated below.—EDIT. GEOL. MAG.



Transverse section through the Costabella range (Middle Triassic limestone); the Campagnazza Meadowland (Lower Triassic mixed deposits and fault-fragments of Permian strata); the slopes of Pellegrino Valley (Permian strata (*Pm.*) and Quartz Porphyry (*Q.P.*)); *ff*, 'Asta' faults; *E.W.*, old east-west fault; *s s*, porphyrite sill and dyke system ascending faults, cleavage-planes, and bedding-planes.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. IX.

No. IX.—SEPTEMBER, 1902.

ORIGINAL ARTICLES.

I. — *Trogontherium* from a Pleistocene Deposit in the Thames Valley.

By E. T. Newton, F.R.S., F.G.S.

THE history of this gigantic rodent began to be written in 1809, when M. Gothelf Fischer described a skull from a sandy deposit on the borders of the Sea of Azof, to which he gave the name of *Trogontherium.* Since then, at varying intervals, to the present time, new chapters have been added to this history by both Continental and British workers, describing specimens of a more or less fragmentary character which have from time to time been discovered. The English specimens have been chiefly obtained from the 'Cromer Forest Bed,' that rich and remarkable series of beds occupying a position in time between the Crags and the Glacial deposits of East Anglia. The 'Forest Bed' specimens were first made known by Sir Charles Lyell in 1840, but were more fully described by Sir R. Owen in 1846 and referred to Fischer's *Trogontherium Cuvieri.* It will not be necessary at this time to refer specifically to each of the additions to our knowledge of this animal or to detail the varying opinions as to affinities and nomenclature, as these particulars will be found in the Memoirs of the Geological Survey of the United Kingdom.[1] Although most of the British specimens of *Trogontherium Cuvieri* have been found in the 'Cromer Forest Bed' a few examples have been met with in the Norwich and Weybourn Crags. The smaller species, which has been called *T. minus,*[2] was obtained from the nodule bed below the Red Crag of Felixstowe, and an incisor tooth from the Norwich Crag was referred to the same species. In 1892[3] the present writer

[1] "The Vertebrata of the Forest Bed Series," 1882, p. 65, and "The Vertebrata of the Pliocene Deposits of Britain," 1891, p. 51.
[2] Quart. Journ. Geol. Soc., vol. xlvi, p. 447.
[3] Trans. Zool. Soc., vol. xiii, pt. 4.

described a remarkably fine skull of *T. Cuvieri*, which had been obtained by Mr. A. Savin from the 'Forest Bed' of East Runton, and is now in the British Museum. The skull named by M. Laugel *Conodontes Boisvillettii*,[1] which is believed to be *Trogontherium Cuvieri*, was obtained from a bed at St. Prest, which is of about the same age as the 'Cromer Forest Bed.' The stratigraphical position of the deposit at the Sea of Azof, which yielded the original *Trogontherium Cuvieri*, still remains uncertain.

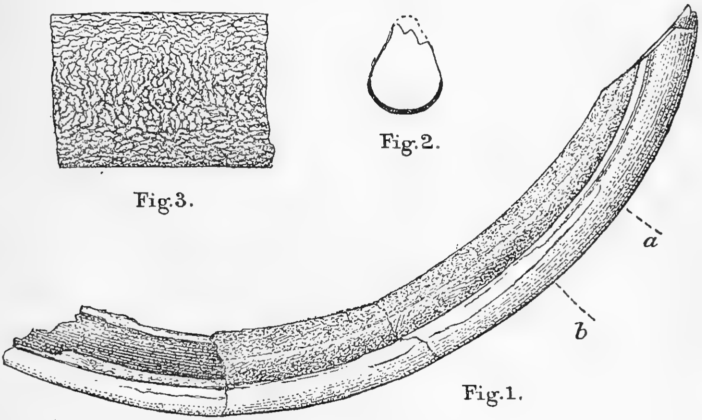
The above sketch will give an idea of our knowledge of *Trogontherium* ten years ago, and no addition seems to have been since made to the history of this interesting rodent. I am now, however, able to record its occurrence in a deposit of Pleistocene age in the lower part of the Thames Valley. In May of the year 1900 Mr. H. Stopes[2] gave an account before the Anthropological Institute of a bed of gravel (at 78 feet O.D.) on the west shoulder of the Ingress Valley, near Greenhithe, Kent, which is remarkable for containing great numbers of *Neritina fluviatilis*, together with many other species of mollusca and vertebrata. The extinct forms included among these fossils showed the deposit to be of Pleistocene age. Mr. Stopes has been careful to preserve all the mammalian remains he could obtain from this bed, but other workers have not been unmindful of the importance of this discovery, and, as may be gathered from Mr. Stopes' paper, they have secured some most interesting specimens. Mr. A. S. Kennard has made a large collection of the mollusca, and Mr. M. A. C. Hinton has obtained many vertebrate remains, chiefly the small forms included in Mr. Stopes' revised list. Another important series of bones has been secured by that assiduous worker Mr. W. J. Lewis Abbott, most of whose specimens are of species included in the published list, but there is one large rodent incisor (Fig. 1) which Mr. Abbott suspected from its size and shape might be *Trogontherium*. A rumour of this 'Great Beaver' from the 'Neritina' deposit seems to have been the cause of *Castor* sp. appearing in Mr. Stopes' list.

This incisor tooth was sent to me some twelve months ago, but I have delayed publishing an account of it, hoping that additional material would be forthcoming. The specimen (Fig. 1) is a lower incisor tooth, as shown by the large diameter of its curve in proportion to its thickness; it measures along the outer curve 132 mm., but is imperfect at both ends. The curve of the tooth, if completed, would form a circle with a diameter of about 150 mm. In cross section (Fig. 2) the tooth is pear-shaped; its width being 11 mm., and from front to back about 13 mm. The front is rounded and the hinder part has been angular, but this edge is nowhere quite perfect. The portion of the front of the tooth, which is covered by enamel, is shown in Fig. 2 by the thick dark part of this outline of the cross section. The inner edge of the enamel is slightly

[1] Bull. Soc. Géol. France, 1862, ser. II, vol. xix, p. 709.

[2] Journ. Anthr. Inst., vol. xxix, p. 302. This paper was reprinted in 1901 with a greatly extended list of fossils—67 species.

grooved from end to end, and the inner side of the tooth, which is not covered by enamel, is slightly concave. There is also a groove along the enamel near its outer edge, but the outer edge itself is rounded. The outer side of the tooth, uncovered by enamel, is slightly convex with an indistinct depression along the middle. The enamel of this tooth is everywhere rugose and granular, as shown somewhat enlarged in Fig. 3. The only large rodent from deposits of Post-Glacial age with which this tooth can be profitably compared is the Beaver. Compared with the lower incisor of a large specimen from the peat it is found to be absolutely longer, even in its present imperfect condition, and to have a markedly greater thickness. These differences of size would not alone suffice to indicate even a specific difference, but are of importance when taken in connection with differences in form and structure. The enamelled front of the Beaver's lower incisor is almost flat, so that the naturally worn cutting edge is straight and chisel-like. The tooth above described has a rounded front, and consequently in wearing would have a more pointed extremity. The enamel of the Beaver's incisor is smooth and shining, not rugose and granular like the present specimen.



Lower right incisor tooth of *Trogontherium Cuvieri* from the Pleistocene of the Thames Valley. Fig. 1, seen from the outer side, natural size; Fig. 2, cross section at *a*; Fig. 3, enamel between *a* and *b*, enlarged two diameters.

The lower incisor tooth of *Trogontherium Cuvieri* agrees with our Greenhithe specimen in all those particulars in which the latter differs from the Beaver; it has a similar rounded front, with rugose enamel, a similar cross section, and is remarkable for its large size. There can be no question as to the Greenhithe tooth being referable to the genus *Trogontherium*, the range of which in time must now be extended to the period of the High-Terrace gravels of the Thames, and it must have been contemporaneous with the fauna recorded by Mr. Stopes, which includes the mammals *Elephas* *antiquus*, *E. primigenius*, *Rhinoceros leptorhinus*, *Bos primigenius*, and the molluscs *Pyramidula rotundata*, *Paludestrina marginalis*, *Unio littoralis*, *Corbicula fluminalis*, etc., together with many Palæolithic implements.[1] As this tooth presents no characters by which it can be differentiated from that of *Trogontherium Cuvieri*, it is provisionally placed in the same species.

II.—On the Genus *Peripristis*, St. John.

By C. R. Eastman, of Cambridge, Mass., U.S.A.

The genus *Peripristis* was established in 1870 by Orestes H. St. John[2] for the reception of two species of Carboniferous fish-remains, one of which had been previously described by Newberry & Worthen under the name of *Ctenoptychius semicircularis*,[3] and was selected as type of the new genus. The other was known in collections and printed catalogues under Agassiz's manuscript title of *Pristodus falcatus*, but this name did not acquire validity until J. W. Davis adopted it in his monograph of 1883.[4] As there can be no question that the two species are congeneric, it follows that St. John's appellation of *Peripristis* has priority over Davis' term, and the type species becomes *P. semicircularis* (N. & W.) instead of *P. falcatus*, Davis.

The claims of *Peripristis* to recognition as a distinct genus were first impugned by J. S. Newberry, who, without having access to the foreign material associated by St. John with *P. semicircularis*, professed himself "unable to recognize more than specific differences"[5] between these teeth and those known as *Ctenoptychius serratus* and *C. dentatus*. Previous to this, however, Newberry had been inclined to separate the American form from other species of *Ctenoptychius*, but had refrained from so doing owing to insufficiency of material at his command for comparison. We find him writing in 1866 that "it is very apparent that the species which have been referred to *Ctenoptychius* require separation," and that the form named by him *C. semicircularis* differs so widely from *C. apicalis*, Ag., as to render it "doubtful if they should even be included in the same genus."[6] A few years later, after his suggestion had been carried into effect by St. John, and without having examined actual specimens of '*Pristodus*,' he saw fit to retract his former views, and his procedure in cancelling St. John's genus has been followed by subsequent writers. It is unfortunate that this error on Newberry's part should have been perpetuated, since even casual inspection shows that the types of *Peripristis* and '*Pristodus*' differ only in minor particulars, and that both are widely removed from *Ctenoptychius*.

[1] These implements have been figured and described by Mr. W. M. Newton in "Man" for June, 1901, art. 66.
[2] Proc. Amer. Phil. Soc., vol. xi (1870), p. 434.
[3] Pal. Illinois, vol. ii (1866), p. 72, pl. iv, fig. 18.
[4] Trans. Roy. Dublin Soc. [2], vol. i (1883), p. 519, pl. lxi, figs. 17–22.
[5] Rept. Geol. Surv. Ohio, vol. ii (1875), p. 52.
[6] Pal. Illinois, vol. ii (1866), p. 73.

Notwithstanding the contrary opinion expressed by Jaekel,[1] we deem it entirely proper to recognize *Peripristis* as the type of an independent family, in view of the specialized character of its dentition. As already suggested by W. Davies[2] and A. S. Woodward,[3] it is probable, though not absolutely certain, that the dental series was reduced in this genus to a single tooth in the upper and lower jaw respectively. This is indicated not only by the form of the teeth, but by marks of contact which show that the opposing teeth interlocked when the mouth was closed, in a manner quite inconsistent with the idea that multiple series were present. The teeth are always bilaterally symmetrical, none having been found which correspond to the lateral series of Petalodonts. If we are to suppose with Jaekel that the symmetrically formed teeth were disposed in transverse series separated from one another by interspaces, then we must needs allow that they were adjusted with almost mathematical precision, and that there could have been not the least lateral play of the jaws in closing. Otherwise it would have been impossible for the functional rows of teeth in opposite jaws to have fitted as accurately into one another as is known to have been the case, the median acuminate apex of the lower teeth being received into a corresponding pit of the upper. So complicated a device as this theory calls for is unparalleled throughout the whole animal kingdom, and sets ordinary mechanical conditions at defiance. It is possible that our German friend has not taken considerations of this nature into account, or he would scarcely have hazarded the opinion "dass Pristodus mehr Querreihen als alle Petalodonten im Gebiss besass, und in deren schwacher Verfalzung die Entwickelung der Petalodonten einleitete. . . . . Wenn wir uns die Zähne von *Pristodus* in derselben Weise auf längere Kieferaste vertheilt denken, wie die von *Orodus* oder *Cladodus*, so hinderte nichts eine ungefähr symmetrische Ausbildung der einzelnen Zähne."[4]

It is the object of the following paragraphs to present a few new facts concerning the structure and distribution of teeth belonging to two species of this genus, namely, *P. semicircularis* and *P. concinnus*.

Family PERIPRISTIDÆ, nomen nov.

Genus Peripristis, St. John.

[Proc. Amer. Phil. Soc., vol. xi (1870), p. 434.]

Syn. *Hoplodus*, R. Etheridge, jun.: Geol. Mag. [2], vol. ii (1875), p. 244.
Diodontopsodus, J. W. Davis: Brit. Assoc. Rept., 1881, p. 646.
Pristodus, J. W. Davis (*ex* Agassiz MS.): Trans. Roy. Dublin Soc. [2], vol. i (1883), p. 519.

Peripristis semicircularis (Newb. & W.).

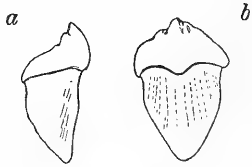
1866. *Ctenoptychius semicircularis*, Newberry & Worthen: Pal. Illinois, vol. ii, p. 72, pl. iv, fig. 18.

[1] Zeitschr. deutsch. Geol. Ges., vol. li (1899), p. 290.
[2] Geol. Mag. [2], vol. ii (1875), p. 243.
[3] Cat. Foss. Fishes Brit. Museum, pt. i (1839), p. 62.
[4] Loc. cit., p. 292.

1870. *Peripristis semicircularis*, O. H. St. John: Proc. Amer. Phil. Soc., vol. xi, p. 434.
1872. *Peripristis semicircularis*, O. H. St. John: Hayden's Final Rept. U.S. Geol. Surv. Nebraska, p. 242, pl. iii, figs. 3, 4; pl. iv, fig. 20.
1875. *Ctenoptychius semicircularis*, J. S. Newberry: Rept. Geol. Surv. Ohio, vol. ii, p. 52, pl. lviii, fig. 14.

It is evident from marks of contact that the relations between the supposed upper and lower teeth of this species are identical with those known to obtain in *P. falcatus*, a specimen of the latter having been described by Davis which displays the dental plates of both jaws in natural association. The tooth which may be provisionally referred to the lower jaw in all these forms is the one which fitted inside that of the opposite jaw when the mouth was closed, the same condition being true of *Janassa*, and of sharks generally. The lower tooth of *P. semicircularis* (Fig. 1) differs from the upper in having the serrations of the cutting edge obsolete, or nearly so, and the inferior coronal margin deflected downward in the median line in front. Its root, also, is longer than that of the upper tooth. The trenchant margin of the latter is always strongly serrated in unworn specimens, there being usually four denticulations on one side of the median line and five on the other; the largest of these may be either central, or in some cases slightly eccentric in position. The coronal cavity of the upper tooth exhibits a deep pit in the

Fig. 1.



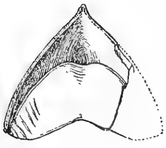


Fig. 2.

Fig. 1.—*Peripristis semicircularis* (N. & W.). Chester Group: Caldwell County, Kentucky. *a*, lateral aspect of lower tooth; *b*, anterior view: nat. size. (The indentations of the coronal margin are caused by contact with the serrated edge of the upper tooth, which closed outside the lower.)

Fig. 2.—*Peripristis bennici* (Ether.). Upper Carboniferous Limestone: Richmond, Yorkshire. Posterior aspect of upper tooth, nat. size.

median line at the junction of the horizontal and vertical portions of the posterior face, but there is no groove extending from it on either side as in *P. falcatus*. Occasionally this pit is developed into a perforation passing entirely through the horizontal portion of the crown. The close contact between upper and lower teeth is indicated by fine vertical markings, and by the impress of the more prominent denticulations upon the outer coronal face of the latter, as seen in Fig. 1.

This species occurs in the Chester limestone of Kentucky, at the summit of the Mississippian series; in the Productive Coal-measures of Ohio and Indiana; and in the Missourian of Nebraska.

Peripristis benniei (R. Etheridge, jun.).

1875. *Petalorhynchus* (?) *benniei*, R. Etheridge, jun.: Geol. Mag. [2], vol. ii (1875), p. 243, pl. vii, figs. 3, 4.
1888. *Pristodus benniei*, R. H. Traquair: ibid. [3], vol. v, p. 101.
1889. *Pristodus benniei*, A. S. Woodward: Cat. Foss. Fishes Brit. Mus., pt. i, p. 64.

This species differs from *P. semicircularis* and *P. falcatus* in that the coronal margin of the upper tooth is not dentated, but acuminate and smooth, and with delicate punctations like the margin of the lower tooth, the latter being as in *P. falcatus.* It is stated by Smith Woodward that all the known teeth of this species, which occur typically in the Lower Carboniferous Limestone of Scotland and Derbyshire, are small in comparison with those of the Yorkshire species, and some doubt is expressed as to whether the non-dentated character of the margin of the upper tooth should not be considered as of generic value. The same author doubtfully assigns one upper tooth in the British Museum to this species, obtained from Richmond, Yorkshire, which appears to differ from the typical teeth only in size.

A second tooth from the same locality as the last, and apparently referable to this species, is preserved in the Enniskillen Collection belonging to the Museum of Comparative Zoology at Cambridge, and is shown of the natural size in Fig. 2. It is quite well preserved, exhibiting the character of the cutting margin with perfect clearness, and showing also several folds on the horizontal portion of the crown. It exceeds the specimen figured by Etheridge in size, and approaches that of *P. falcatus.* As the upper tooth of *P. concinnus* (Davis) has not yet been definitely recognized as such, there are no means of determining whether its coronal margin was serrated, as in *P. semicircularis* and *P. falcatus*, or smooth and acuminate, as in the species under discussion. In the latter event it would probably be difficult to distinguish between the upper teeth of *P. concinnus* and *P. benniei*, unless size alone were a criterion. The slight extent to which the coronal apex is produced in the present specimen, however, does not warrant its association with *P. concinnus* in the present state of our knowledge. Hence it may be affirmed that *P. benniei* accompanies the two other British species of *Peripristis* at the Richmond locality.

III.—The Wood's Point Dyke, Victoria, Australia.

By F. P. Mennell, F.G.S., Curator of the Rhodesian Museum, Bulawayo.

THE Wood's Point Dyke is intrusive in a belt of Silurian (Upper Silurian) strata which strike in a direction somewhat west of north and extend beyond Walhalla on the south. Wood's Point is about 75 miles from Melbourne in an easterly direction, and is not situated on the coast as might be inferred from its name. The nearest sea-water is, indeed, some 60 miles distant. The dyke has a north-west by south-east bearing, and it may be taken as typical in many respects of the intrusions which are frequently associated with the Silurian rocks of the Victorian goldfields, though it presents several peculiar features of considerable interest. It penetrates strata of different lithological characters, and, as might be expected, varies considerably both in texture and in the relative abundance of its mineral constituents along its course. That absorption of the surrounding rocks has taken place to a considerable extent may be taken for granted from certain of the modifications which are exhibited. In several particulars, however, specimens from different points along the outcrop agree, not only with one another, but with many of the other Victorian Palæozoic but post-Silurian intrusions. We have, indeed, an illustration of what seems to be a general rule, that precisely similar minerals tend to develop in all parts of the same magma, even when the various portions differ considerably in chemical composition, unless the variations reach an extreme point. In other words, the relative acidity or basicity of different portions are expressed by differences in the proportions of the same minerals rather than by the development of other minerals of more acid or more basic character.

Hand-specimens representing the average appearance of the Wood's Point rock are dark-coloured and distinctly granitic in texture. The specific gravity ranges as high as 2·9, and the closeness of grain enables it to retain a good polish which might make it valuable in the future for ornamental purposes. Under the microscope it is seen to depart widely from a truly plutonic structure. Hornblende is the dominant constituent, though both augite and enstatite are also present. It forms larger crystals than any of the other minerals, but it is certainly not 'porphyritic' in the strict sense of the term. The word 'porphyritic,' if it has any real scientific application at all, must be held to characterize a mineral as of prior consolidation to, if not as actually belonging to an earlier generation than, the remaining constituents. In the present instance, despite its relative development, the hornblende rarely shows the crystal outline which would indicate early consolidation. In fact, it is sometimes moulded on felspar, and there are even indications of an ophitic structure in the occasional penetration of a crystal by idiomorphic crystals of the latter mineral. The colour of the hornblende is brown, which, as pointed out by Teall,[1] is seldom or never the case with the varieties derived from augite

[1] "British Petrography," p. 166.

That it is original in the present instance can scarcely be doubted, despite the occurrence of the pyroxenes. The prism angles, where seen, are those proper to the species, and there are no traces of the wedge-shaped outgrowths or fibrous structure so characteristic of the uralitic varieties. The pleochroism is striking, giving deep yellow brown for $\mathfrak{c}$ to nearly colourless for $\mathfrak{a}$, while the interference tints are frequently to some extent masked by the strong absorption. The extinction angle in longitudinal sections reaches a maximum of 18°, while a twin in which the sharp boundary of the individuals showed it was cut parallel to the clinopinacoid, gave 13° on each side of the composition plane.

The pyroxenes are distinguished from the hornblende by their cleavage and extinction angles and their want of colour. The augite shows distinctly stronger refraction and double refraction than the hornblende, while the enstatite gives low interference tints and shows the straight extinction in several longitudinal sections. The augite is sometimes surrounded by hornblende; it may, however, be regarded as an inclusion in the latter rather than as intergrown with it.

FIG. 1.—Hornblende Porphyrite. Crossed nicols, × 50 diam.

The felspar does not all belong to the same period of consolidation; indeed, it seems to have been developed in at least three distinct generations or regenerations. The largest crystals, those which are idiomorphic towards the hornblende, belong to the first period, smaller crystals and microlites represent the second generation, while other small crystals, much the freshest constituents of the rock, must be regarded as in all probability of secondary origin. The first class have undergone decomposition to such an extent that they are nearly opaque. They appear, however, to extinguish almost straight, and unless this is an effect of decomposition they would seem referable to oligoclase. The second series are somewhat fresher and exhibit both the Carlsbad and Albite types of twinning, though the lamellæ in the latter case are never numerous. A few examples show Pericline lamellation as well. The maximum extinction angle in cases where the lamellæ give approximately symmetrical extinctions is about 21°, so that the species appears to be andesine. The third variety includes examples which are clear, and are often indistinguishable from quartz, except by convergent light, in cases where there is no twin lamellation. In a few instances they show a decomposed core, and the peculiar form of zoning is also seen which Professor Judd[1] has ascribed to growth after the consolidation of the rock. Well-marked lamellar twinning is sometimes shown, and the species approaches albite, though the outer layers are evidently more acid than the interior, as shown by their increasing angle of extinction. There is yet another form of felspar to be described, that which occurs in considerable abundance intergrown with quartz. In places it gives to a slice the appearance of a typical granophyre. The quartz and felspar occasionally radiate in pseudo-spherulitic fashion from a centre, which is sometimes marked by an idiomorphic crystal of decomposed felspar. The felspar of these micrographic intergrowths is usually referred to orthoclase, microcline, or other acid type; in the present instance decomposition prevents any attempt to determine the variety. The quartz frequently presents beautifully sharp triangular sections, contrasting markedly with the cloudy felspar. Larger isolated granules also occur, but for these a secondary origin is generally to be suspected.

Of what are usually termed accessories ilmenite is by far the most abundant, being even noticeable on a polished surface of the rock. It is, no doubt, the source of the 'titaniferous ironsand' so common in the auriferous wash of the neighbourhood. Incipient forms of growth are the rule even in the largest crystals, which are usually built up of plates or rods intersecting at angles of 60° and 120°, the best developed ones giving a somewhat elongated hexagonal section. In many cases the mineral is quite fresh; frequently, however, leucoxene has been formed through interaction with the decomposing felspars. Occasionally the change has been complete, and nothing remains but a semi-opaque patch of leucoxene, but in most instances the internal structure of the original mineral is revealed in a most striking manner, a lattice-work skeleton of ilmenite being often left which shows up beautifully by reflected light. Apatite is another accessory and is also common. Some of the prisms are short and stout, and show good terminations; usually, however, the crystals are acicular and very long, several so thin as to be almost opaque, attaining a length of nearly 2 mm. Pyrites and calcite occur as decomposition or infiltration products, but they call for no special notice. There is also a micro- or crypto-crystalline groundmass present in most slices, and what seems to be some residual glass. It is almost colourless, and looks perfectly homogeneous by ordinary light. Between crossed nicols, however, it shows feeble double refraction, with here and there an approach to spherulitic structure. It has been suggested to me that this might possibly

[1] Q.J.G.S., May, 1889, p. 179.

be a chloritic or serpentinous decomposition product, but from its relation to the other minerals this seems very unlikely, and it may be looked upon with some certainty as devitrifying glassy material.

The above description applies to the leading (and most basic) type, which may be classed as a hornblende porphyrite, the term porphyrite being applied in the sense of a hypabyssal equivalent of the diorites. A few varieties, apparently coarser-grained in the hand-specimen, show, curiously enough, considerably more crypto-crystalline groundmass, while in the finer-grained varieties the hornblende is much more frequently idiomorphic and takes on forms similar to the basaltic variety. One fine-grained marginal modification is very acid in character, being of a grey colour in hand-specimens and showing minute cavities. The silica, kindly determined for me by Mr. L. Ludlow, reaches the high figure of 77·4 per cent. The chief feature of interest is the occurrence of cordierite, distinguished by its peculiar twinning and its biaxial interference figure in convergent polarized light. Most of the granules show some approach to crystal outline and are twinned, the interference tints of the individuals being different in cases where the extinctions are simultaneous. One crystal, though not quite perfect, nevertheless well illustrates the multiple twinning of the mineral (see Fig. 2). It differs from the form figured by Rosenbusch[1] in the fact that the twin planes bisect the sides, not the angles, and the boundaries of the individuals are somewhat irregular, while an extra one is wedged in between two of the others.

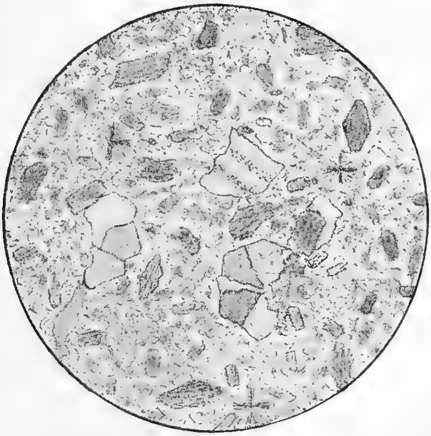


Fig. 2.—Cordierite Felsite. Crossed nicols, × 50 diam.

Osann has accounted for the presence of primary cordierite in a somewhat similar rock as due to the complete absorption of fragments of cordierite gneiss, resulting in the local formation of a magma containing an abnormal percentage of alumina, from which cordierite crystallized out in due course. In this case we have no

[1] "Mikroskopische Physiographie," pl. xviii, fig. 1.

cordierite gneiss to account for the occurrence, but we have plenty of aluminous material in the adjacent shales, and, as Teall has justly pointed out,[1] there is no reason why the mineral should actually be present in the absorbed rock. None of the other minerals which are genetically connected with cordierite and almost constantly accompany it are present in the numerous slices I have examined, unless some small brilliantly polarizing crystals are to be referred to sillimanite. No separate determination of the alumina has been made, but the combined alumina and ferric oxide come to 19·8 per cent., an extremely high figure in so acid a rock, leaving less than 3 per cent. unaccounted for, after taking the silica into consideration. The iron certainly cannot be present in large quantities, ilmenite, pyrites, etc., being entirely absent from this part of the rock, while the ferro-magnesian minerals (chloritized hornblende and granular augite) are very sparingly distributed.

The intrusion of such dykes as the one described is evidently related to the formation of the associated auriferous veins. In the case of the Victorian Silurian deposits the reefs are almost invariably connected with intrusive rocks, while those in the Ordovician strata usually occur at or near the contact with great plutonic masses. It seems highly probable, as Mr. Howitt has suggested,[2] that on following down a dyke formation it would be found to end as a contact deposit on reaching its plutonic source. At Wood's Point the reefs are nearly horizontal, traversing the dyke and the shales in the immediate vicinity, the junction usually marking the occurrence of rich ore. Mineralization evidently went on coincidently with or very soon after the intrusion of the dykes during Devonian times; indeed, in New South Wales and in Queensland, where the conditions are very similar, detrital gold has been worked in mechanical sediments of Lower Carboniferous and Permo-Carboniferous age.

Where the gold came from is a question not easy to answer. Some of the Victorian dykes have been found on analysis to contain gold, sometimes as much as $\frac{1}{2}$ oz. to the ton, but it may always be argued that the enrichment of the dyke was due to the same causes as that of the lodes themselves. It seems to be generally believed that the mineralization took place from below; to my mind, however, the evidence seems to point to the leaching out and redeposition of the minute quantities of gold present in the shales by the action of heated acid waters connected with the intrusion. A fact which has, however, frequently struck me is the almost invariable association of gold in this class of deposit with rocks containing *original* hornblende, and it has been noted in New South Wales that in every case where auriferous reefs are associated with granite the latter is hornblendic.[3] Whether there is any significance in this association remains to be seen, but it certainly seems worthy of further investigation.

[1] Pres. Address to Geol. Assoc. 1899.

[2] "The Downward Extension of Quartz Reefs": Ann. Rep. Chamber of Mines of Victoria, 1901, p. 36.

[3] G. F. Pittman: "Mineral Resources of N.S.W.," p. 62.

IV.—A Fragment of Physical Geography: The Past and Present of a bit of Dartmoor.

By Harford J. Lowe, F.G.S.

INSTANCES of alteration of the courses of streams are common, but these changes are met with for the most part in the alluvial plains and flood areas at low elevations where the streams are approaching their termination in sea or lake. The instance here noticed is of a rarer kind, where a small Devonshire stream, the Bovey River, has accomplished, with the help of contributory forces, earth sculpture apparently enormously out of proportion to its present insignificant dimensions, and managed to shorten its journey to join the Teign by altering the direction of the middle part of its course at a point where its elevation is considerable.

The village of Lustleigh is well known to most visitors to South Devon as a resort frequented for its beautiful situation and surroundings. It lies on the eastern edge of Dartmoor where three narrow and precipitous valleys join the broader one which runs from Bovey to Moretonhampstead. Lustleigh is particularly distinguished to visitors by what is called the Cleave. The name, instead of being used for the valley or cleft, is in popular parlance applied to a ridge of granite of wedge shape about two miles and a half in length, upon the slopes of the narrow end of which most of the village of Lustleigh lies. This end of the 'Cleave' is crowned by a noble disorder of granite masses which is named from a rocking-stone, much used for the purpose indicated, 'The Nut Crackers.' From here in a north-west direction the crest of the ridge gently rises to another Tor or assemblage of bare granite masses called Raven Rocks, beyond which the ridge widens and rises to 1,068 feet, and near some ancient earthworks is given the very appropriate name of Hunters' Tor, in that it is a most excellent view point in all directions. This ridge, which for convenience sake I will call as a whole the Cleave, is in some respects unique amidst Dartmoor scenery, in that it more than any other portion of Dartmoor is cut away from the main elevated moorland by valleys and depressions on all sides. In consequence, from several points of view it commands particular notice by standing out in apparent independence, while all other prominences are seen to be connected, by only slight depressions in the skyline, to the central area of Dartmoor.

As shown in the accompanying sketch-map, the north-east and south-west boundaries of the 'Cleave' are formed by narrow deep valleys, which meet at the wedge point where the confluent streams have an elevation of less than 200 feet above the sea-level. The Bovey River flows along the gorge on the south-west, while on the north-east a tiny stream has cut a valley from the northern part of the Cleave parallel to the Wray, which half a mile to the east over an intervening elevation of only 700 feet occupies the Moretonhampstead valley.

The northern boundary of the 'Cleave' is marked by a depression along which a motley assortment of ill-grown trees and undergrowth has obtained possession. This narrow band of wood-covered land is found on closer examination to be very uneven ground, made up for the most part of ridges and holes evidently of artificial arrangement. The place, with its repellent pools of stagnant water, overhung by sprawling trees whose roots and lower branches bear trails of green slime left on them by the subsiding water, strikes one as a weird spot, fit home for the Dartmoor pixies. Locally the place

Fig. 1.—Sketch-map of a portion of the Eastern border of Dartmoor. The numbers indicate the heights in feet above O.D.

is known as Peck Pits, and has been referred to by a native as a 'ghastly place.' The disturbance of the material, probably by the old tin streamers, reveals a considerable depth, some 20 feet or more, of gravel, varying in consistence from coarse sand to a rubble of from 3 to 5 inches in diameter. A crude arrangement of the material as regards size can be made out, the coarser lying at the foot of the Tor. All the stones of which this deposit is formed are much water-worn, many being quite rounded, with few that are better described as subangular. The deposit rests upon and is well within the granite area. and contains nothing outside the products of the granite mass. Most of the material is derived from the hardest varieties of the granite, viz., the schorl rock, elvans, and quartz veins; but the former constitutes much the greater proportion of the coarser material, and there is very little of the more easily disintegrated porphyritic granite to be met with.

Receding from the foot of the Tor the drift material becomes finer, and finally as sand mixed with humus forms cultivable land. A cutting made by a roadway through a portion on the opposite side of the strip from the Tor shows sand of varying degrees of coarseness, roughly stratified, with the finer material increasing upwards.

From the description it will be seen that the materials are all water-worn and water-borne, and are sorted out after the manner of river drift where a stream, turned from a direct course, by wearing away the opposing mass loses much of its carrying power while increasing the area of drift deposit at the bend.[1]

There is, then, little doubt that this drift now lying far above the present bed of the Bovey stream is the work of that river, a deposit made in its earlier and probably more vigorous age, when its course was along the north side of Hunters' Tor and down the broader Moretonhampstead valley, now occupied by the puny Wray stream. But while it was expending its force in shearing a drift area on the north side of the Tor, a small stream on the south-west of the Cleave was cutting its way back in a north-westerly direction and thus gradually approaching the bend of the larger stream, until the gradually narrowing ridge dividing the principal from the subordinate valley became worn down to the level of the higher and main stream, when it would leave its old circuitous course and descend the more direct and precipitous one towards its destination. The old course and the approaching valleys are indicated on the following map.

Half a mile south of the river-deserted patch of gravel and near to the newer and present course of the Bovey stream stands the farmstead of Foxworthy, remembered probably by some who may read this note as the moorland retreat of a well-known geologist and friend of geologists—Mr. A. R. Hunt, M.A., F.G.S., etc., who directed the Geologists' Association for the day and entertained them at this delightful spot (Easter, 1900).[2] To him I am much indebted for geological help, and indeed he introduced the problem of the drift, a solution of which is here offered. Close to Foxworthy estate is a peculiarity in the channel of the river that may be accounted for by the turning of the greater stream into the course of a small tributary. Horsham Steps (see Map 1) is an extraordinary aggregation of granite boulders choking the river channel for a considerable number of yards. These boulders are, generally speaking, very massive, so that the interstices are sufficiently large to allow all the water to pass through them except at times of freshets of more than average volume. The boulders are so piled together that they form a natural fording-place at most states of the stream, which at

[1] References to the valley deposits are made in papers by G. W. Ormerod, Quart. Journ. Geol. Soc., vol. xxiii, p. 425, and Prestwich, Geol. Mag. for 1898, p. 414.

[2] Proc. Geol. Assoc., vol. xvi, p. 430.

ordinary flow is almost hidden several feet below the highest 'steps.' Now it is well known that granite weathers irregularly. Frequently harder cores occur which resist decay and stand above the disintegrated surface. These, by processes due to temperature, denudation, and gravity, gradually make their way to the bottom of the valley. They are to be met with in most granite areas, scattered about in what might paradoxically be called an irregularity that has a kind of uniformity about it. Now Horsham Steps has no parallel that I am aware of, and it seems to me probable that the boulders found their way into the bed of the minor stream in

Fig. 2.—Former drainage of same area as represented in Fig. 1.

the usual scattered fashion, but that the somewhat sudden increase of the stream by the addition of the waters of another river with much greater volume increased its force and carrying power sufficiently to drive together the boulders strewn along a rapid portion of its course, in such a manner that they formed a support to each other and thus became an immovable barrier and unusual feature.

As there are data upon which to base calculations, it will be of interest to form some idea of the time which has elapsed since the river changed its course. Lord Avebury, in his "Scenery of England," cites Croll as estimating the mean rate of erosion by rivers as one foot in 3,400 years. Mr. Charles Davison (Geol. Mag., December, 1889, p. 411) gives reasons for thinking a foot in 2,400 years more probable. Now if we take the average of these estimates, and make allowance for the probably more rapid lowering of the bed of a river in its earlier history, as well as steeper parts, we might take 2,500 years per foot as the index of erosion for the Bovey stream in its upper course. As shown on the map the old river gravel stands at an elevation of 750 feet, while the present height of the river at that point where it changed its course is 630 feet, so that it might be taken that it has followed its present course west of the Cleave for some 300,000 years. Yet this is but a short stage in its history, for from data used by Professor Sollas in his address to Section C at the Bradford Meeting of the British Association, it must be some 3½ millions of years ago since this same stream was helping to fill up the Eocene lake and depositing the material that is known as 'the Lignite formation of Bovey Tracey.'

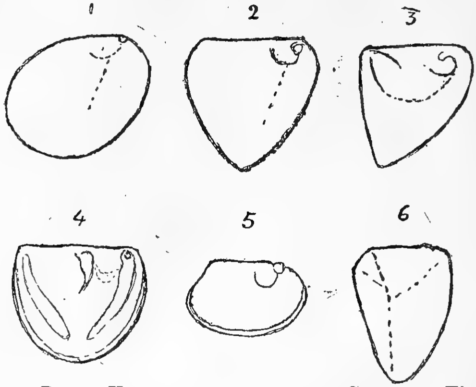
V.—Notes on Dr. G. F. Matthew's Cambrian Ostracoda from North-Eastern America.

By Professor T. Rupert Jones, F.R.S., F.G.S.

For many years Dr. G. F. Matthew, of St. John, New Brunswick, has given much attention to the geology and fossils of the districts lying on or near the north-eastern seaboard of North America, and has closely studied their minute fossils resembling (if not identical with) varieties of small bivalved Entomostraca; and he has published his results from time to time in the scientific periodicals of Canada and the United States.

One of the first of his descriptive memoirs on these peculiar microzoa is in the Transactions of the Royal Society of Canada, vol. iii, 1886, and treats of some of these remarkable little organisms from the St. John's Group of Cambrian strata, at pp. 61–66, figs. 16–21, under the names of *Lepiditta, Lepidilla, Hipponicharion,* and *Beyrichona,* some being regarded as Ostracoda and others doubtfully as Phyllopoda. They were referred to in the Reports British Association, 1889, p. 174, and too hastily supposed to be possibly opercula of Pteropods; they must evidently be accepted as members of the Ostracodous group.

The terminology used by Dr. Matthew for these little organisms can be readily collated and fitted in with the descriptive terms used by other palæontologists for similar or allied forms. The modifications of the ovate-oblong valves and of their relative convexity are not strange, except that the ventral border in some of these forms is very much expanded obliquely downwards and backwards, becoming more or less triangular. The 'ocular tubercle' is high up in the antero-dorsal corner or angle of the valve; and is often accompanied or surrounded by a circular indication of what Dr. Matthew regards as the mark of the anterior adductor muscle. The central muscle-spot, common in the Leperditian family, is not recognized. Most of the described specimens the author refers to the new family Bradoriidæ; and they appear to be allied to *Aparchites* and *Leperditia*. *Hipponicharion*, by its superficial ridges, seems to be the only representative of the Beyrichiidæ.



Outlines of the Right Valve of some of the Genera.—Fig. 1, *Indiana*; 2, *Bradorona*; 3, *Beyrichona*; 4, *Hipponicharion*; 5, *Bradoria*; 6, *Escasona*.

In pl. i of the memoir No. 10, figs. 1–6 (here copied) are: "Diagrammatic figures of genera to show important characters referred to in the text—*o*, ocular tubercle; *m*, scar of adductor muscle; *c*, cardinal or hinge-line; *a*, anterior cardinal curve; *b*, posterior cardinal curve; *c*, anterior marginal curve; *d*, posterior marginal curve; *v*, ventral margin."

The small letters *o* to *v* are omitted for the sake of clearness in these copies, but the features referred to are sufficiently distinct.

The following list indicates the succession and subjects of those of the above-mentioned memoirs that contain descriptions and often illustrations of these very ancient Entomostracan remains:—

No. of Mem.	Date.	Particular Faunæ and Formations.	
1	1886	Lower Cambrian: St. John Group	Trans. Roy. Acad. Canada, vol. iii.
2	1890	Lower Cambrian	Trans. Roy. Acad. Canada, vol. vii.
3	1894	Lower Cambrian	Trans. Roy. Soc. Canada, vol. xi.
4	1895	*Protolenus*-zone	Trans. New York Acad. Sci., vol. xiv.
5	1896	*Paradoxides*-zone	Trans. New York Acad. Sci., vol. xv.
6	1898	Cambrian: St. John	Trans. Roy. Soc. Canada, ser. II, vol. iv, sect. 4.
7	1899	Etcheminian group of Cape Breton	Bull. Nat. Hist. Soc. New Brunswick, VIII, vol. iv.
8	1899	Etcheminian group of Newfoundland	Trans. Roy. Soc. Canada, ser. II, vol. v, sect. 4.
9	1899	Etcheminian group of Newfoundland	Bull. Nat. Hist. Soc. St. John, New Brunswick, XVIII, vol. iv.
10	1902	Etcheminian of Cape Breton ...	Canadian Record Sci., vol. viii.

The geological formations or terranes of the north-eastern part of America concerned in Dr. Matthew's researches are noted in the memoir No. 4, p. 102, as—

Upper Cambrian ...	*Ceratopyge* fauna	Upper Tremadoc.
	Peltura fauna	Lower Tremadoc.
	Olenus fauna	Lingula Flags.
Lower Cambrian ...	*Paradoxides* fauna	Menevian and Solva.
	Olenellus fauna [1]	Caerfai Group.

[1] At p. 105 referred to the Etcheminian stage of Pre-Cambrian age.

The St. John Group in the Cambrian terrane of New Brunswick is given in memoir No. 4, pp. 105 and 109, as follows :—

CAMBRIAN	Division 3.	Bretonian ...	*Tetragraptus* fauna.
	,, 2.	Johannian ...	=place of the *Olenus* fauna.
PRE-CAMBRIAN...	,, 1.	Acadian ...	*Paradoxides* and *Protolenus* fauna.

The Ostracoda peculiar to the three divisions or zones of the Etcheminian terrane underlying the St. John Group in Cape Breton, and to the still lower Coldbrook terrane, are tabulated at pp. 438 and 439 in memoir No. 10.

LIST OF GENERA AND SPECIES OF OSTRACODA FROM LOWER PALÆOZOIC STRATA, DESCRIBED BY DR. G. F. MATTHEW, 1886–1902.

DATE.		MEMOIRS.	DATE.		MEMOIRS.
1886.	*Hipponicharion eos*	1, 2, 3	1895.	*Schmidtella Cambrica*	4
1894.	,, *cavatum*	2, 3	1899.	,, ? *pervetus* and	
1894.	,, *minus*	2, 3		1 mutation	7, 10
1886.	*Beyrichona papilio*	1, 4	1899.	,, *avita*	7, 10
1886.	,, *tinea*	1, 5	1898.	*Beyrichia* ? *primæva*	6
1895.	,, *planata*	4	1899.	*Bradoria*[5] *scrutatrix*[6]	7, 10
1895.	,, *triangula*	4	1899.	,, *vigilans* and	
1895.	,, *ovata*[1]	4		3 mutations	7, 10
1895.	,, *rotundata*	4	1899.	,, *rugulosa* and	
1886.	*Primitia acadica*	1, 4		1 mutation	7, 10
1894.	,, *aurora*[2]	3, 4	1899.	,, ? *ornata*	7, 10
1895.	,, *oculata*[2]	4	1899.	*Aptychopsis terra-novica*	
1895.	,, ? *fusiformis*	4		and 1 mutation.	8, 9
1898.	,, *pyriformis*	6	1902.	*Bradorona*[7] *perspectrix*	
1886.	*Lepidilla*[3] *alata*	1, 5		and 3 mutations	10
1886.	,, *anomala*	1	1902.	,, *spectatrix* and	
1886.	,, *curta*	1, 5		3 mutations	10
1894.	,, *auriculata*	3, 5	1902.	,, *observatrix* and	
1894.	,, *sigillata*	3, 4		1 variety and 2 mutations	10
1890.	*Leperditia* ? *ventricosa*	2	1902.	*Escasona*[8] *rutellum*	10
1890.	,, ? *Steadi*	2	1902.	,, ? *vetus*	10
1895.	,, ? *minor*	4	1902.	,, ? *ingens*	10
1895.	,, ? *primæva*	4	1902.	*Indiana ovalis* and 1	
1902.	,, *rugosa*	10		mutation.	10
1895.	*Aparchites*[4] *secundus*	4	1902.	,, *lippa*	10
1898.	,, ? *robustus*	6			

In the foregoing list there are enumerated 13 genera, comprising 43 species, with 1 variety and 15 mutations (changes or stages).

[1] *Beyrichona ovata* of the *Protolenus*-zone is referred to the genus *Escasona* at p. 458 of memoir No. 10.

[2] *Primitia aurora* and *P. oculata* are referred to the genus *Bradoria* at p. 452 of memoir No. 10.

[3] *Lepiditta* and *Lepidilla* have λεπις, a scale, for their root.

[4] Another species of *Aparchites* (*A. conchiformis*) is referred to at p. 454 of memoir No. 10 as belonging to the *Protolenus*-zone.

[5] *Bradoria* is derived from the Lake 'Bras d'or' (!), in Cape Breton.

[6] *Scrutatrix* is corrected from *scrutator*. So also *perspectrix*, *spectatrix*, and *observatrix* are corrections.

[7] *Bradorona* is regarded as the augmentative of *Bradoria*.

[8] *Escasona* seems to have been derived from Escasonie in Nova Scotia (see memoir No. 4, pp. 444 and 445), or Cape Breton (ibid., pp. 454 and 456). We may note that the genera *Kirkbya* and *Kloedenia* are referred to and misspelt here and there in the text.

VI.—Note on the Upper Chalk of Lincolnshire.

By William Hill, F.G.S.

In the Geology of East Lincolnshire, a memoir of the Geological Survey published in 1889, the whole of the flint-bearing Chalk of that county above the Melbourn Rock was referred to as Middle Chalk, and no horizon was found which could be regarded as the equivalent of the zone of *Holaster planus*, or the Chalk Rock of the Midland counties.

As our knowledge of the fossils of the Upper Chalk increased, the occurrence of *Infulaster excentricus*, *Echinoconus globulus*, and *Rhynchonella limbata*, which had been collected by Mr. Rhodes from a quarry at Acthorpe, near Louth, suggested to Mr. Jukes-Browne that there might after all be some part of the Upper Chalk exposed in north-east Lincolnshire; and for the purpose of obtaining evidence on this point I made two visits to this locality in 1897 and 1898, and was fortunately enabled to establish the fact of its existence in this county. The zone of *Holaster planus* was well marked in a quarry near Boswell Farm, half a mile north-west of North Elkington, about three miles north-west of Louth. The section here was as follows:—

	ft.	in.
Clayey gravel and chalk rubble	6	0
White chalk with three layers of large flat flints and some scattered flint nodules. *Echinocorys scutatus*, *Micraster Leskei* ...	5	6
Firm white chalk, *Micraster Leskei*	3	0
A thick continuous floor of flint	0	5
White chalk, rather harder, with *Holaster planus*, *Micraster Leskei*, and *Echinocorys scutatus*	2	9
A thick layer of intermingled chalk and flint	0	8
Firm white chalk with a layer of large flat flints (partly obscured)	6	0
Harder chalk with two layers of intermingled chalk and flint ...	7	0
	31	4

The typical fossils of the zone occurred in the upper part of the section only; the specimens of *Micraster Leskei* were large ones.

Quarries to the eastward between Elkington and Fotherby, and again near North Ormsby, expose another set of beds, which must be very nearly on the same horizon as those at Boswell, and are different from any seen to the south of Louth. These beds have been described in the memoir of the Geological Survey, and are characterized by the existence of continuous floors of grey flint, each about 6 inches thick, these flint layers often containing inclusions of hard yellowish chalk. Fossils are not common in these beds; Mr. Jukes-Browne informs me that Mr. A. Burnet, of Leeds, has recently found some in the quarry about three-quarters of a mile west-south-west of Fotherby, though unfortunately they are not sufficient to prove the exact age of the Chalk containing them. Mr. Jukes-Browne has identified them as follows: *Septifer lineatus* (in flint), *Inoceramus Brongniarti*? *Plicatula sigillina*, *Rhynchonella Cuvieri*, *Serpula* sp., and a spine of *Cyphosoma*. The occurrence of *Septifer lineatus* is noteworthy, as it is not uncommon in the zone of *Holaster planus*, but it is curious that Echinoderms should be so rare in this set of beds.

There is no appreciable dip in either of the above-mentioned quarries, and it is therefore impossible to say for certain whether the chalk near Fotherby is stratigraphically higher or lower than that at Boswell, but the balance of available evidence is in favour of their being a little lower, for the Fotherby quarry is at a rather lower level than the other, and the absence of *Echinocorys* suggests a lower horizon.

Similar chalk with intercalated layers of flint extends northwards along the eastern border of the Chalk Wolds, and exposures of them are mentioned in the Survey memoirs on the geology of Sheets 83 and 86, but no fossils indicative of Upper Chalk were obtained from any of them. In 1899, however, I found Chalk with *Holaster planus* in a quarry half a mile south-east of Kermington, near Brocklesby, where the following succession was visible :—

	ft.	in.
Soil and rubble	4	0
Hard white chalk, weathering into thin irregular platy pieces ...	1	9
Continuous layer of solid grey flint	0	5
Hard white chalk as above, with layer of flat lenticular flints ...	3	6
Continuous layer of solid grey flint	0	6
White chalk, rather soft and shaly, at the top *Holaster planus* ...	1	0
Hard white chalk, breaking into thin flattish pieces	3	6
Grey flint, nearly continuous, but separated in places into detached tabular flints	0	6
Hard white chalk with only a few scattered nodular flints ...	9	0

From the lithological characters seen here I believe this quarry is just in or just below the zone of *Holaster planus*. In the large Chalk quarries at Barrow I found a good specimen of *Echinocorys scutatus*, besides fragments which I should refer to this species. The lithological features of the Chalk at this horizon are well marked ; the Chalk itself is firm, almost hard, and weathers into thin platy pieces, becoming softer at the higher horizons. The flint, besides occurring in the ordinary nodular form, occurs also in lenticular masses five or six inches thick, which can only be described as 'tabular,' though they do not form the even continuous floor seen in the tabular flint of the South Coast cliffs. They present rather the appearance of a series of large mammillated flints all on the same plane, merging in places to one unbroken layer of considerable extent.

From the foregoing evidence the fact that Upper Chalk occurs in Lincolnshire seems well established. I could find, however, no evidence to indicate an exact horizon which could be taken for its base, nor could I find a quarry or series of quarries to give me the passage of Chalk with flint nodules in the zone of *Terebratulina* to that of Chalk with the tabular flint layers.

The lithological features which are associated with *M. Leskei*, *H. planus*, and *Echinocorys scutatus*, viz., firm chalk with layers of massive tabular flint, passing upward to softer chalk with nodular flint, continues through Yorkshire. For instance, *H. planus* associated with *Echinocorys scutatus* occurred in chalk with massive tabular flint in the railway cutting just west of Enthorpe Station, near Market Weighton. The overlying chalk was softer with flint nodules, and here and there a tabular layer.

A small quarry at the turning of the lane to Goodmanham Lodge Farm showed three layers of tabular flint. *Holaster planus* was common in the Chalk. The position of this quarry is just beyond a cutting (now grassed over) in the railway west of Kipling Cotes Station, where Mr. Allen, collector for the Geological Survey, found *Micrasters* now referred to as *Micraster præcursor*. The horizon of the quarry is a little lower than the cutting.

The Chalk in Yorkshire containing layers of flint has been noticed by Professor Blake, who, unable to agree with the divisions of Barrois, formulated a classification based on the characters of the flints.[1] He gives a thickness of 50 feet to "Chalk with tabular flint," and calls it the barren zone. This "Chalk with tabular flint" is undoubtedly the continuation of that of Lincolnshire, and we may take it as being roughly the equivalent of the nodular Chalk of the south-east of England and of the Chalk Rock of the Midland counties.

VII.—On some Examples of Marine and Subaerial Erosion.

By Horace Woollaston Monckton, F.L.S., F.G.S.

On the excursion of the Geologists Association to Gower last Easter our Director, Mr. R. H. Tiddeman, showed us a series of examples of the celebrated raised beach, and a good deal of discussion arose as to its relation to the other recent deposits of the district. Into those questions I do not propose to enter on this occasion, but will accept, what all admitted, viz., that the beach is an old sea beach, that the platform upon which it rests is the work of the waves, and that it has been raised to its present position by earth-movement.

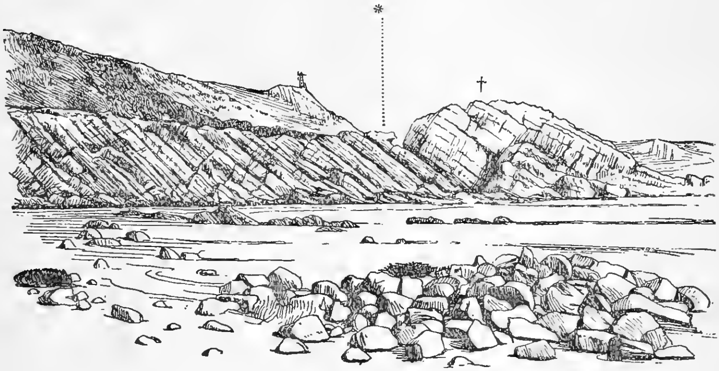
The platform is formed of solid rock, Carboniferous limestone, which for the most part dips at a very high angle, so that the old beach rests upon the upturned edges of the strata. We were shown one particularly interesting example between Caswell Bay and Brandy Cove; there the rock platform is some 20 feet above the present beach.

Its top is fairly level, but a transverse section would probably show a dip seawards. The old beach has become consolidated into a calcareous breccia, and rests on the platform, which has been somewhat eroded in places, so that in one place the beach projects beyond it. Close by, Mr. Tiddeman drew our attention to a rounded knob of rock rising a few feet above the platform, which had no doubt stood out above the shore and projected through the old beach. The irregularities of the platform under the beach are no doubt largely due to the fact that it is limestone and subject to decay underground. In one locality on the coast to the left of the estuary near Penard Castle our Director showed us a place where the platform is overlain by, and consequently protected by, a considerable thickness of beach

[1] "On the Chalk of Yorkshire": Proc. Geol. Assoc., 1878, vol. v, p. 232.

and rubble. I noticed the surface was then much more regular, the line cutting through both limestone and calcite very evenly.

We may therefore describe the platform as a tolerably level plain, with here and there knobs of rock projecting above it, and it is most instructive to compare it with the shore in front of it. The sea is now taking another slice off the upturned limestone beds. Gradually the old beach is removed, then the old platform is worn into a collection of jagged points, and these are by degrees planed away, and a new and fairly flat rock floor is cleared with a slope seaward. Still, some parts take longer to wear away than others, and knobs of rock stand up in places. What the width of the old beach may be I do not know, perhaps no wider than the modern platform in front of it.



View of Cliff between Caswell Bay and Brandy Cove, looking East.
* Here a portion of the Raised Beach projects.
† Knob of Carboniferous Limestone rising above Raised Beach.

I was more especially interested in these platforms as I have some acquaintance with a similar feature on a very much larger scale on the coast of Norway. It was described by Dr. Hans Reusch in the Year Book of the Norwegian Geological Survey for 1892–93 (Kristiania, 1894), and I have since had opportunities of examining parts of it.

The coast plain, as Reusch terms it, extends along most of the coast. Like our Gower platform it is cut in solid rock; it runs like a shelf along much of the mainland, and forms many an island. In the case of other islands it runs all round them, producing an appearance which has been compared to a hat floating on the sea, crown uppermost, hence such names as Torghatten ('market hat').

The coast plain is usually but little elevated above the sea, and rises towards the land to a height which varies in different places. Dr. Reusch thinks its topmost limit is about 300 feet. Its surface is rounded and ice-worn, and he places the date of its formation either before the Ice Age, or during intervals in that period when the coast was free from ice.

The coast plain is particularly well seen near the mouth of the Hardanger Fjord. Mountains and low hills rise sharply above the flat, which is dotted with houses and farms. At first sight this flat might be taken for sand or gravelly shore deposit, but walking over it one finds that it is solid rock with but little superficial accumulation. This flat belongs to the coast plain. In most cases it looks flatter from the deck of a boat than when one is upon it. In fact, there are many hummocks like the one Mr. Tiddeman showed us on the old Gower platform. There are also valleys no doubt excavated since the coast plain rose above the sea.

Most of the towns of the Norwegian coast stand on the coast plain, and I may take Bergen as an example, since I know it well myself, and it is probably also known to many of my readers. Bergen is for the most part built on solid rock, the Bergen Schist. The rock is worn into irregular hummocks, with a tendency to a N.W. and S.E. trend. One of these projects between the two harbours forming the Nordaes; on its top stands the old fort Fredriksborg, nearly 100 feet above the sea. Rock is seen all around the fort and out to the end of the peninsula. Inland the rock slopes downwards, and there is a flat space known as the meadow (Engen), on both sides of which fairly steep streets run down to the sea.

On the opposite side of the harbour to the north another knob of rock bears the fort Sverresborg, and to the south a smaller knob forms Sydnaes. This irregular rock surface is all coast plain, and it is sharply marked off from the mountains which rise from it very abruptly on both sides. Inland the valley between the mountains continues, and in it are some small lakes; probably when the sea stood at the level of the coast plain this was a 'sund,' and the mountains south-west of Bergen formed an island.

The coast plain is well marked around Os, south of Bergen, and there, as in many other places, I noticed how abruptly the higher hills rise from a flat rock coast plain.

Dr. Reusch remarks that all the way from Stavanger northwards to Aalsund the coast plain is for the most part bare rock, without any covering of loose material. He gives a few exceptions, such as the brickfields near Bö on the east side of the north of Karm Isle, a tract round Fitje Church on Storen, and the Isle of Herlö north of Bergen.

Around Aalsund, he says, there is a good deal of glacial gravel. At the same time, as I saw myself, a good deal of rocky coast plain is exposed near and north of Aalsund.

The coast plain of Norway, like the raised rock platform of Gower, is, I take it, a base-level of marine erosion, and is evidence that the sea at the time of its formation stood higher or the land lower than it does now. The probability is that it is the level of the land which has altered, for though the old coast plain is now above the sea along nearly the whole coast, it is believed by Reusch to have been depressed below sea-level in the neighbourhood of

Statland. The well-known headland there rises sheer from the sea, but he remarks the steep slope does not go far down under water. The fishery charts show that the 50 fathom line is from 2 to 3 miles from the land, and in that distance there are sunken rocks rising to, or nearly to, the surface, that is to say, they belong to the coast plain now under water.

In the north of Norway Dr. Reusch notes that the coast plain is duplicated. He more especially refers to the tract around Torghatten, the celebrated island, the mountain upon which has a hole through it. There we see two coast plains, the upper with a level of about 300 feet and the lower forming the usual flat stretch a little above the sea. We should get a similar result in Gower if further elevation were to take place now, for the present sea-shore would form a second raised platform, and the sea would then begin to cut another slice off the rocks at its new level.

It is not easy, in most cases, to prove by any definite evidence whether a tract of surface is the result of marine erosion or has been produced by subaerial denudation. The platform upon which the Gower raised beach lies is clearly the work of the sea, and I think Dr. Reusch has established the coast plain of Norway as being the work of the sea too, though it has no doubt been somewhat modified by subaerial denudation, and more especially by ice-action since its elevation. On the other hand, it has been found possible to prove that the wide flat plateaux of South and East Berkshire and the neighbouring parts of Surrey and Hampshire are the work of subaerial eroding agents. They are largely covered by sheets of gravel, which has been proved by its peculiarities of composition to be gravel of different rivers (Q.J.G.S., 1892, vol. xlviii, p. 29). In fact, these flat Berkshire and Surrey plateaux were the bottoms of valleys at the time of the deposition of the gravel which caps them, and the gravel being harder than the sides of the valleys has better resisted the agents of denudation.

That it is possible to produce definite evidence in this case is, however, due to conditions which do not hold in all places. Thus the valleys of the country around London are, to a large extent, newer than the Drifts which lie at high levels around them, and to a large extent the Drifts have either survived or are newer than the Ice Age. In many parts of England the surface of the solid geology is hidden by great accumulations of Glacial Drift, and in mountainous regions, such as North Scotland and Norway, the rock surface has been swept clear of all soft deposits by ice, and we have only the beds of gravel, sand, clay, etc., which have been left by, or have accumulated since, the retreat of the last glacier or ice-sheet.

The district at the head of the Hardanger Fjord, in Norway, has especial attraction for me. It is, for one thing, not yet free from ice, and a snowfield, the Hardanger Jökl, covers a considerable tract. In the second place, the main surface features seem to be the result of subaerial denudation. Dr. Hans Reusch has quite recently dealt with this question in the Year Book of the Norwegian Geological Survey for 1900 (Kristiania, 1901), and I am much interested to find that he is even more subaerial—if I may use such an expression—than myself. The best known of the valleys at the head of the Hardanger Fjord is that leading up to the celebrated waterfall, the Vöringfoss. At the top of the fall is the Fosli Hotel, and if we mount up to it we find ourselves upon a wide stretch of moorland with rounded hills and wide open valley, through which flows the River Bjoreia. Whatever may have been the origin of this surface it has been clearly modified by ice-action, for all the rock surfaces are smoothed and rounded and erratic blocks abound. I noticed one boulder of coarse granite, 6 feet high, on the moor, and there are many others of considerable size. How long a time may have elapsed since these boulders were brought to this spot I cannot say, but the perpetual snow probably covered the ground in quite recent times, for the Hardanger Jökl is only some 8 miles away to the north-west, and I believe only about 2,300 feet above Fosli, the level of which is about 2,200 feet. There is a good deal of peat on the moor, and it looked thick in places, but I could find no other superficial deposit. Though there is a general rounding of the outlines of mountain and valley here, I could see nothing which suggested a platform of marine denudation like the Norwegian coast plain. There seemed no point of which one could say, "Here the mountain rises abruptly from the plain," as one so often can in the case of the coast plain. It is true the notch of the old margin might have become full of talus, but with the exception of the slopes of one mountain, Grytefjeld, there seemed very little talus. On the whole it seemed to me that these valleys were the result of subaerial denudation. In this I find Dr. Reusch concurs, and he classes this moorland as belonging to what he names the Palæic surface of Norway. So far as Norway is concerned he is disposed to define this surface as the surface which existed with its principal features before the Quaternary Period, and thus the surface of Tertiary or even older times.

If I am right in thinking that the gravel of Chobham Ridges, in Surrey, is a river gravel of the earliest Glacial or even of Pliocene date (Q.J.G.S., vol. liv, p. 193), then the surface upon which it lies is a bit of the Palæic surface of England, the bottom of a Palæic valley in fact. In Norway, where the rocks are hard, we have the Palæic hills and valley, with its river still flowing through it, the whole, no doubt, much modified by ice-action. In Surrey, though there was no glacier so far as we know, the floods, etc., of the Ice Age have almost removed the old surface, leaving only the bottom of the valley where it was protected by river gravel.

The old land surface of Hardanger stands now some 2,000 and more feet above the sea, and in it a series of narrow and deep valleys have been cut out, and into these valleys the rivers flow to the fjord. Thus the Bjoreia, after flowing in the broad open valley of the old surface, suddenly falls 500 feet into the head of one of these deep valleys (Maabodal), the fall being the Vöringfoss. To the north the next stream of any size falls over the steep side of the Simodal as the Skykjedals fall, and the next into the head of the same dale as the Rembesdals fall. Returning to Surrey, we find that something also occurred there, for the river which had deposited the Chobham Ridges Gravel, now at a level of 400 feet above the sea, appears to have deepened its valley and deposited the sheets of gravel on the side of the Fox Hills, now at a level of about 250 feet. Dr. Reusch suggests that the result in Norway was produced by a rise of the land, and I have made a similar suggestion with regard to Surrey ("Origin of the Gravel-Flats of Surrey and Berkshire," GEOL. MAG., N.S., Nov. 1901, Dec. IV, Vol. VIII, p. 510).

I will leave the valleys, however, and return to the high ground of Hardanger. To obtain a general idea of it let us ascend one of the mountains on the north of the Fjord, say one of those above Norheimsund; then looking south and south-east across the fjord we see the long flat snowfield, Folgefond, stretching above all along the skyline. To the left the top is a little lower and merely dotted with snow patches, one prominent summit, Haarteigen, standing above the general level to about the height of the snowfield. A little to the north, but hidden by nearer mountains, is the Hardanger Jökl snowfield, also rising above the mountain-tops around it. Now what are we to say about this, the topmost plain of the country? Is this a plain of marine erosion, or have we in it another old plain of subaerial denudation, or peneplain as some authors would term it? Dr. Reusch decides in favour of the latter explanation. He says (p. 131), "The high mountain expanses of Norway are most likely, as a rule, peneplains—I do not say a peneplain, for probably they do not all belong to the same geological time. . . . . One district where this can be exemplified is, for instance, the high mountain region north and north-east of the Hardanger Jökl. Above the open stretches, where the saeters are, there rise higher plateau-shaped mountains the surface of which seems as though it were the remains of another and older peneplain." Thus we have Hallingskarven, 1,951 metres; Hardangerjöklen, with about the same altitude; Bleien, 1,696 metres; Blaaskavlen, 1,773 metres, etc. And he gives (p. 134) a map on which he marks these and other plateaux, as well as Haarteigen and the Folgefond, as remains of the older peneplain. He adds that the level of the highest plateau seems to be independent of the geological rock formation; thus it rises above the line where we have a tolerably horizontal boundary between the Grundfjeld (mostly gneiss) and the Cambro-Silurian schists.

I refrain from going further into the question now, and content myself with the remark that I think Dr. Reusch has clearly shown that an alteration in the level of the sea almost of necessity causes changes of the land surface, which extend far inland, and the commencement of a new land surface at a new level; and if this is the case amongst the hard rocks of Norway, how much greater must be the effect of a change of sea-level where the inland rocks are soft as in the south of England!

VIII.—A Geologist of the last Century.

Dr. Ferdinand von Roemer, the Father of the Geology of Texas: his Life and Work.[1]

By Frederic W. Simonds, Austin, Texas.

(WITH A PORTRAIT, PLATE XIX.)

FERDINAND ROEMER, who has justly been called the "Father of the Geology of Texas," was born at Hildesheim, Hanover, on January 5th, 1818. His early education was obtained at the Gymnasium Andreanum of that town, where, under the influence of his teacher, Dr. Muhlert, he developed a great fondness for science, especially in the line of natural history. His love of geology, however, was strongly developed by excursions with his eldest brother, F. A. Roemer, Frederic Hoffmann, and F. A. Quenstedt. Notwithstanding his predilection in this direction, he was induced by his brother, probably with the view of entering a well-established profession, to undertake the study of law. Accordingly, from 1836 to 1839 he was engaged in attending legal instruction at Göttingen, with the exception of the Summer semester of 1838, which was spent at Heidelberg. Still, the attraction of science was well-nigh irresistible. With the keenest pleasure he listened to Hausmann on geognosy, and when at Heidelberg the zoological instruction of Bronn was eagerly sought. His future calling was, however, to be decided in favour of his natural bent. As he was about to present himself for examination in the higher legal course, for political reasons — although he himself was an innocent party — certain difficulties were raised and he withdrew. Thus science gained a brilliant scholar and geology a zealous investigator.

Going to Berlin (1840) he came within the influence of such men as Weiss in mineralogy, von Dechen in geology, especially that of Germany, Gustav Rose in geognosy and mineralogy, Mitscherlich and H. Rose in chemistry, von Lichtenstein in zoology, Johannes Müller in anatomy and physiology, Dove in physics, and Steffens in anthropology.

On May 10th, 1842, he received the degree of Doctor of Philosophy, having presented a palæontological dissertation entitled "De Astartarum genere et speciebus quae e saxis iurassicis et cretaceis proveniunt."

The time spent at Berlin had an important bearing upon his future in still another direction. It was here that an intimate friendship sprang up between him and von Dechen, Beyrich, and Ewald, and his intercourse with them led, on his part, to a wider comprehension of geology and a better understanding of the methods to be pursued in research. About this time he became engaged in a series of investigations in the Rhenish mountains which covered the Summer season of several years. The results of this work were published in 1844, under the title "Das rheinische Übergangsgebirge. Eine palaeontologisch-geognostische Darstellung." The

[1] Reprinted by kind permission of the Editor, Dr. N. H. Winchell, from *The American Geologist*, vol. xxix, March, 1902.

Yours very sincerely
Dr. Ferd. Roemer

next year (1845) his first contribution to the *Neues Jahrbuch für Mineralogie, Geologie, und Palaeontologie* appeared, and thereafter for more than forty years his name was familiar to the readers of that journal.

He now (1845) entered upon that part of his career which is of the greatest interest to Americans, especially Texans. With means provided in part by the "Berliner Akademie der Wissenschaften," and with the warm personal endorsement of the celebrated traveller and explorer, Alexander von Humboldt, he undertook a journey to America for the purpose of studying its geology and palæontology, in the course of which he spent a year and a half in the then little known state of Texas. Here, to judge from the results of his investigations, his activity must have been very great, for, in addition to contributions furnished to the American Journal of Science and Arts in 1846 and 1849 (ser. II, vols. i and vi) and a more popular work entitled "Texas. Mit besonderer Rücksicht auf deutsche Auswanderung und die physischen Verhältnisse des Landes," published at Bonn in 1849, he gave to the world in 1852 "Die Kreidebildungen von Texas und ihre Einschlüsse. Mit einem die Beschreibung von Versteinerungen aus paläozoischen und tertiären Schichten enthaltenden Anhange und mit II von C. Hohe nach der Natur auf Stein gezeichneten Tafeln," printed also at Bonn, by Adolph Marcus. It was this work that won for him the title "Father of the Geology of Texas." That Roemer should have been able to accomplish so much during his brief sojourn in the state is remarkable considering the limited means of transportation and the serious danger from wandering bands of Indians when conducting scientific work outside of the immediate vicinity of the settlements. Under such circumstances, that his results should have been so accurate is little short of phenomenal.

Before proceeding farther it may be well to direct attention to some of the salient points brought out by these early investigations. "Die Kreidebildungen" is not entirely devoted to the Cretaceous or Chalk formation of Texas, for, in addition to a detailed consideration of that formation and its fossils, the introduction treats of such topics as the following: "Geographic Position and General Orographic Character of Texas," in which the greater topographic features of the state, with the exception of the western mountains, are clearly described; "General Geognostic Constitution of the Land"; "Diluvial and Alluvial Formation"; "Tertiary Formations"; "Older or Palæozoic Strata"; and "Plutonic Rocks." The Appendix, moreover, contains descriptions of fossils from the Palæozoic strata and descriptions of fossil woods by Professor Unger. In view of the above outline it scarcely need be said that this work has been a fruitful source of inspiration to all who have made a special study of the topographical and geological features of this region. That it, as well as the earlier descriptive volume, should not have been translated into English long ago, is somewhat remarkable. Concerning the geological map in the earlier volume, based upon Wilson's geographical map, it is fair to say that the general features of the state are well shown and with an unexpected degree of accuracy.

But Roemer's American studies were by no means confined to Texas. In 1860 he published "Die Silurische Fauna des Westlichen Tennessee; eine Palaeontologische Monographie," with five plates.

In June, 1848, he became Privat Docent in mineralogy and palæontology at Bonn. That his studies in Texas were still uppermost in thought is apparent from the title of his probationary discourse, "Eine übersichtliche Darstellung der Geognostischen Verhältnisse von Texas." His natural gifts as a teacher rendered possible, in 1855, the call to an ordinary professorship in the University of Breslau, in connection with which he became Director of the mineralogical cabinet. Here he found a few minerals, scarcely sufficient to meet the needs of instruction in a realschule, stored away in most inaccessible quarters. At once he determined to undertake the laborious task of making a great collection. How well he succeeded is shown by the fact that he left to his successor one of the richest and best arranged collections of minerals and fossils in any of the Prussian universities.

In 1861, to the great satisfaction of his colleagues and friends, he declined a flattering call to Göttingen. Five years later, in 1866, his fidelity and labour were rewarded by the removal of his collections into a new and commodious building, erected largely after his own plans, on the Oder, between Schuhbrücke and Universitätsplatz. In arranging the collections in their new apartments Dr. Roemer was ably assisted by Oberbergrath Martin Websky, who under his influence soon resolved to devote himself entirely to science, becoming first extraordinary professor at Breslau and later the successor of Gustav Rose at Berlin. It was not a small matter to have discovered such a man. But his influence with his students was also great, for on the list of those who, under the inspiration of his teaching, took upon themselves science as a life-work we find such names as H. Credner, W. Dames, K. Hintze, Cl. Schlüter, Th. Liebisch, H. Eck, K. von Seebach, T. Tietze, and others who have gained recognition in the learned world. Indeed, no better evidence of his unusual power as a teacher is needed. Says one of his students: "His love of teaching, his ready utterance, his kindly care for his pupils, remained unchanged to the end. When well advanced in years he taught with the same zeal, the same vivacity, and the same clearness that characterized his work when a young man."[1]

While his activity in the routine duties of his professorship was very great it was not less in the direction of research and investigation. In the *Neues Jahrbuch f. Min. Geol. und Pal.* Dr. Dames has listed over 350 titles of publications in the interval between his graduation, in 1842, and his death in 1891, many of which represent long and patient investigations. While it would not be possible within the limits of this sketch even to mention all the subjects covered, for they are of wide range, attention may be called to

[1] Dames.

a few other than those already alluded to in the preceding pages. During the years 1852–1854 he published in connection with its author a revision of H. G. Bronn's "Lethaea geognostica oder Abbildung und Beschreibung der für die Gebirgs-Formationen bezeichnendsten Versteinerungen. Bd. i, 2: Palaeo-Lethaea; Kohlen-Periode (Silur, Devon, Kohlen- und Zechstein-Formation)." More than twenty years later we find him again engaged upon an enlarged and revised edition of this work. The atlas, with 65 plates, appeared in 1876; in 1880 the first part of the text, and in 1883 the second part. It is a matter of regret that he did not live to complete this undertaking. In 1861 he published "Die Fossile Fauna der Silurischen Diluvial-Geschiebe von Sadewitz bei Öls in Niederschlesien." This was in the form of a "Gratulationsschrift" of the Silesian Society to the Breslau University at its jubilee held that year.

In July, 1862, the preparation of a geognostic map of Upper Silesia on the scale of 1 : 100,000 was authorized by the Prussian Ministers of Commerce, Trade, and Public Works, and Roemer was selected to direct its construction. For eight years, assisted by O. Degenhard, H. Eck, and A. Halfar, he devoted himself to this work, and at the same time made numerous short contributions announcing new discoveries in the geology and palæontology of that region. These served as forerunners of the "Geologie von Oberschlesien," a work in three volumes, published in 1870, which contained the complete results of the investigations of himself and his assistants. The great value of this publication is evident when we take into consideration that up to this time little was known of the geology of the province, which had long been famous for the value of its mineral deposits.

After the publication of this work he found time not only to rewrite portions of "Lethaea Palaeozoica," to which reference has already been made, but to prepare numerous smaller contributions treating of his investigations and studies, among which may be found the first observations upon the discovery of diluvial mammals in the low plain of Northern Germany, especially in Silesia and Poland. So great was his interest in this direction that later he undertook an investigation of the Polish bone caves, concerning which he published in 1883 a large work bearing the title "Die Knochenhölen von Ojcow in Poland" (Palæontographica, xxix). This was translated into English by John Edward Lee, under the title "The Bone Caves of Ojcow in Poland," and published the following year in London.

As further evidence of Roemer's great activity, it may be remarked that he had already prepared and published (1880) a description of the Carboniferous Limestone fauna of the west coast of Sumatra—"Uber eine Kohlenkalk Fauna der Westküste von Sumatra" (Palæontographica, xxvii)—based upon a fine collection sent him in 1876 by Verbeek.

In 1885 appeared "Lethaea erratica" (Palaeont. Abhand. von Dames u. Kayser, Bd. ii, 5, Berlin), embracing an enumeration and description of the boulders occurring in the North German plain.

Among his papers published in 1887 is the description of a fossil Crustacean from the Shoal Creek region near Austin, entitled "*Graptocarcinus Texanus*, eine Brachyure aus der oberen Kreide von Texas," with an illustration (N. Jahrb. f. Min., etc., 1887, Bd. i, 173). The next year he published the description of "*Macraster*, eine neue Spatangoiden-Gattung aus der Kreide von Texas" (N. Jahrb. f. Min., etc., 1888, Bd. i, 191), represented by *M. Texanus* from Georgetown. The same year he also published "Über eine durch die Häufigkeit Hippuriten-artiger Chamiden ausgezeichnete Fauna der oberturonen Kreide von Texas" (Paleont. Abhand., Bd. iv, 3 plates). The fauna here considered is from Barton's Creek, a well-known locality a short distance south-west of Austin. Of the twenty-one species described he regarded eighteen as new. Objection has been justly taken by the students of Texan geology to the assignment of this fauna to the Upper Turonian, for, as a matter of fact, the strata are Lower Cretaceous, and cannot be correlated with that formation.

But Roemer was a mineralogist as well as a geologist and palæontologist. In a practical way this was shown in his great work at the Breslau Museum. His love for minerals was strong, and his knowledge such that he was envied by the younger men who specialized in that line. It has, however, been said that his greatest service to mineralogy was that he "saved" to that science the incomparable Websky.

Again, Roemer was a man of wide experience in travel. Not only did he visit North America, but in Europe every country and some countries several times; England in 1851, 1866, 1871, 1876, and 1880; Ireland in 1883; Holland and Belgium in 1854; Sweden in 1856 and 1878;[1] Austria and Upper Italy in 1857; Piedmont and Bohemia in 1858; Norway in 1859; France in 1860; Russia in 1861; Turkey in 1863; Spain in 1864 and 1872; Switzerland in 1869. These journeys, his numerous publications, and an unusual aptitude in acquiring foreign languages, made him probably the best known German geologist of his time.

As would naturally be expected, his long and active career brought him many honours, both at home and abroad. In recognition of his great service to science he was invested with a title by the State, and elected to membership in many of the learned societies, among which may be mentioned the Geological Society of London, 1859; the Royal Academy of Science, Berlin, 1869; the Imperial Academy of Science, St. Petersburg, 1874; the Royal Bavarian Academy of Science, Munich, 1885. In the year last mentioned he was also the recipient of the Murchison Medal of the Geological Society.

[1] It was Dr. Woodward's good fortune to know Dr. Ferdinand Roemer for many years (from 1858 to nearly the end of his life). Travelling on a geological excursion in the Eifel with Mr. John Edward Lee, F.G.S., in the Autumn of 1878, they met, quite accidentally, Dr. Ferdinand Roemer near Gerolstein, and with him as geological guide and most genial of companions, they spent a never-to-be-forgotten fortnight, visiting with their historian all the most interesting Devonian fossil localities, and examining the extinct craters (now crater-lakes) in that delightful country. In the following year Mr. Lee and Dr. Roemer made an expedition to Faxe in Denmark to study this very interesting uppermost Cretaceous deposit.—Edit. Geol. Mag.

Roemer's knowledge was not, however, entirely confined to science, though its range here was surprisingly great; he was also well informed in the classics and *belles lettres.* His nature was winning, his manner attractive, and his influence with the young great. It scarcely need be said that he had many friends and admirers. Although happily married for twenty-three years he was childless, yet his love of children was shown in the rearing of his wife's nieces as his daughters.

It was his great good fortune to be able to look back upon a life rich in opportunities and fruitful in results. He had expressed the hope that the end might find him in the full possession of his powers rather than burdened with the infirmities of old age, and his wish was granted. He died at Breslau on December 14th, 1891, in his 74th year.

NOTICES OF MEMOIRS, ETC.

1. Canada (?).—"A Summary Report of the Geological Survey Department for the Calendar Year 1901, printed by order of Parliament, *Ottawa*, 1902," has reached us; but nowhere in the title do we discover its country of origin. From internal evidence, however, we gather it comes from Canada. The report is full of interesting matter, contains two new *Trionyx*, illustrated, from the Cretaceous of Alberta, but suffers from the want of an index, or at least chapter headings. In these busy days 269 pages of Report are apt to be considered as mere Report unless the reader is furnished with a clue to the contents.

2. Pyrenean Volcanoes.—Patrick W. Stuart-Menteath describes the volcanic phenomena of the Pyrenees in a series of papers published in the Boletin de la Sociedad Aragonesa de Ciencias Naturales (Zaragoza), a new serial of which we have seen No. 5 of vol. i (May, 1902).

3. The German Geological Society.—Dr. E. Koken has published (Berlin, 1901) "Die Deutsche geologische Gesellschaft in den Jahren 1848–1898, mit einem Lebenabriss von Ernst Beyrich," with a portrait of Beyrich. It is interesting to recall the names of the founders of the German Society—von Beust, Beyrich, von Buch, von Carnall, Ehrenberg, Ewald, Girard, von Humboldt, Karsten, Mitscherlich, J. Müller, Rose, Weiss.

4. Maryland.—The fourth volume of the Maryland Geological Survey (*Baltimore*, 1902) deals with "Palæozoic Appalachia, or the History of Maryland during Palæozoic time," by Bailey Willis. This is a highly interesting physical and dynamical paper, and is well illustrated. A second report on Highways by Messrs. Reid & Johnson contains results of tests of road materials and technical notes on road construction. Heinrich Ries contributes a long report on the Clays of Maryland, both from a geological and economic point of view. We again recommend the get-up of this publication to the notice of the Geological Survey of the United Kingdom.

5. The Conflict of Truth.—This is a book by Mr. F. Hugh Capron, apparently written to reconcile Religion and Science. To those who are interested in this matter these 509 pages of argument may prove more absorbing at this time of year than throwing pebbles into the sea. There are chapters on "the six days of the formation," "the antiquity of man," and divers other matters. Publishers, Hodder & Stoughton, 1902; price 10*s.* 6*d.*

6. A New Meteorite.—Mr. Geo. P. Merrill describes some 20,000 grams of meteorite which fell at Admire, Lyon County, Kansas, probably 30 years ago. It is a pallasite and belongs to Brezina's Rökicky Group, consisting of metallic iron and olivine.

7. Tarcoola.—The Record of the Mines of South Australia, issued by H. Y. L. Brown in 1902, deals with "Tarcoola and the North-Western District." The report is concerned mainly with the goldfields. The mass of the country consists of Cambrian (?) and metamorphic rocks, with Tertiary conglomerates and gravels, but there are gypseous clays at Lake Cadibarrawirracanna. A geological sketch-map is appended.

8. Foraminifera.—Among the recent publications on this group may be mentioned Rhumbler's important paper on the double shells of *Orbitolites* and other foraminifera, with excellent illustrations, published in the Archiv für Protistenkunde, 1902. The author deals with and endeavours to explain the curious 'twinning' so common in *Orbitolites.* Messrs. R. B. Newton and R. Holland describe in the Journ. Coll. Sci. Tokyo, 1902, Bryozoa and Foraminifera from the Formosa and Riu-Kiu Islands; there are four plates, chiefly rock-sections showing organisms, and a figure of an *Operculina* which appears to have been an inch in diameter. Schlumberger (Bull. Soc. géol. France, 1901) figures *Orbitoides media,* d'Arch., and other forms of the genus, and discusses the genus in general; in another note (Samml. Geol. Reichs-Mus. Leiden, 1902) he describes a remarkable quadristellate *Lepidocylina* from Borneo. Barrois records the genera *Endothyra, Textularia, Lagena*? and *Valvulina*? from the Carboniferous phtanites of the Boulonnais (Ann. Soc. géol. Nord, 1902); and Lomnicki mentions the occurrence of *Globigerina* and *Sphæroidina* in the Miocene sands of Léopol (Kosmos, Lemberg, 1902). Fornasini, ever busy in this group of animals, has papers on three species of *Textularia* and a *Polymorphina* founded by d'Orbigny in 1826, a continuation of his valuable notes on forms described but not figured hitherto; on O. G. Costa's *Faujasina*; on the date of publication of Costa's "Foraminiferi di Messina"; and on the nomenclature of "*Nautilus* (*Orthoceras*) *pennatula*" of Batsch: all these papers appear in the Rivista Italiana di Paleontologia for 1902. Schubert discusses Defrance's genus *Textularia,* and with Liebus records foraminifera from the Devonian (Etage G–g_3, Barr.) of Bohemia (Verh. k.k. geol. Reichs., 1902).

9. Ostracoda of the Basal Cambrian Rocks of Cape Breton.[1]—Dr. G. F. Matthew has described a considerable number of species

[1] Canadian Record of Science, 1902, vol. viii, No. 7.

of Ostracoda, and three new genera from the rocks older than the Paradoxides Beds but included in the Cambrian system. The author claims that these forms differ in many respects from the species of the Ordovician system, and have a unity of structure sufficient to place them in a new family distinct from Leperditiidæ, etc. Many of the species have wide valves, more or less pointed on the ventral margin; most have long hinge-lines and an ocular tubercle. The scar of the adductor muscle, in place of being near the middle of the valve as in many Ordovician species, is close to the anterior end of the cardinal line. Twenty-seven forms are described, arranged as follows:—*Leperditia* (?), 1 species; *Bradorona* (subgen.), 3 species, 8 mutations, and 1 variety; *Bradoria*, 3 species and 1 doubtful, 1 mutation; *Escasona*, 1 species and 2 doubtful; *Indiana*, 2 species and 1 mutation; *Schmidtella* (?), 2 species and 1 mutation. Two of these forms are found in the basal volcanic terrane of Coldbrook; the rest are distributed through 500 feet of the Etcheminian terrane, occurring in twelve assises of that group in company with various Brachiopods. Two plates accompany this article in which are figured the various species and mutations described. Outline figures are also given to show the more obvious characters of the new genera.

REVIEWS.

I. Etude Géologique sur l'Isthme de Panama; par MM. Marcel Bertrand et Philippe Zurcher. II. Les phenomènes Volcaniques et les Tremblements de Terre de l'Amérique central; par M. Marcel Bertrand. Quarto; pp. 38 in all, with plans and sections; published 1899.

I.

THE long-standing controversy between the advocates of the Panama route and those of the Nicaragua route for the great American interoceanic canal has apparently at the last moment been decided in favour of the former. Apart from the struggles of politicians this decision seems to be by far the most sensible, since property which even in its present state is worth something like £8,000,000 sterling must of necessity represent an asset of considerable value. It would seem not altogether improbable that the recent catastrophe in the Windward Islands has had its due effect in impressing upon the politicians at Washington the possible dangers of the Nicaragua route, which were so forcibly pointed out by Professor Bertrand in these memoirs more than three years ago, dangers foreseen by nearly all scientific men, and whose lessons just at present are well burnt into the mind of the Transatlantic public.

Since the time when the second great work of Mons. de Lesseps was commenced a new generation has appeared upon the scene, but it may not be without interest on the present occasion to quote a portion of an article which appeared in *Nature*, August, 1885, entitled "Piercing the Isthmus of Panama," an article evidently written in an optimistic spirit which is rather amusing in the light of subsequent events. It commences as follows :—

"Three years ago the work of cutting through the Panama Isthmus had barely commenced. The equatorial forests on the neck of land, 73 kilometers long, which marked the axis of the future interoceanic canal, had hardly been laid bare. The traveller who followed the primitive road met here and there some groups of cabins with roofs of branches on poles, marking the site of a sounding or the improvised dwellings of a portion of the operators. Culebra, Emperador, Corosita, and Gamboa, which are now full of activity, were then almost desert, and on the coast of Colon alone the excavator traced in the marshy plains of Gatun his great track. The contrast to-day is great: a long file of workshops covers the space between the Atlantic and the Pacific. Twenty thousand workmen toil on the Cordillera, making the deep cutting for the canal. Side by side with this army, another more powerful army of colossal machines, excavators, dredges, locomotives, waggons, all the materials for transport, thousands of pairs of wheels, hundreds of kilometres of sails, mountains of coal, and shiploads of dynamite. Among the twenty-five workshops of the peninsula the attention is chiefly attracted to two points: the great rocky cutting at Culebra, which is to penetrate to a depth of 120 metres into the Cordillera, and the dam of the Chagres at Gamboa. At Culebra the previsions of M. de Lesseps have been realised: the mountainous mass which the canal will traverse is, for the most part, composed of rocks which are not very hard; repeated soundings by means of diamond perforators have shown that down to a considerable depth the rock takes the form of schists [*sic*] in horizontal strata. There is no doubt that it can be cut through with rapidity; it is a matter of perforation, either by mining and ordinary explosives, or by shafts with larger quantities of some explosive to displace great masses. Here 30,000 cubic metres of rock have been displaced by an explosion of dynamite; and unquestionably this colossal channel connecting two seas may be executed by simple methods and with economy."

The article from which the above extract is taken was probably written by an engineer rather than by a geologist, but the writer gives us an interesting picture of work then going on, *and we may shortly expect to see such work renewed to the finish.*

Meanwhile, it will be convenient to consider the geological aspects of the question as set forth in the two short though important memoirs to which Professor Bertrand has mainly contributed.

In dealing with the subject of previous publications the authors state that the actual base of our knowledge of the age of the beds of Panama is to be found in two notes published by M. Douvillé in 1891 and 1898. The first of these notes was founded on the examination of a series of fossil specimens collected by M. Canelle, a former engineer of the Canal Company. The second, of which a *résumé* only has already appeared (December, 1898), has had for its starting-point the study of the fossils brought by M. Zurcher. The authors also refer to the works of Messrs. Hill, Dall, Wagner, and Boutan in this connection.

The Panama memoir is illustrated by two coloured sections—one a general section of the whole 74 kilometres of the canal; the other, on a larger scale, of the great cutting (Emperador and Culebra) between the 48th and 56th kilometres. The range in time covered by these sections extends from the Tongrian with Nummulites to the Quaternary, the Aquitanian and Miocene being represented, but the Pliocene being absent.

General Structure of the Isthmus: Rock of Gamboa.—The oldest formations occur in the centre of the Isthmus, where their outcrop forms a large undulating plateau; these pass under more recent beds on both sides, the general arrangement being a very flattened anticline. The central part is formed by a volcanic rock—the rock of Gamboa, which is described as consisting of breccias and lava-flows, with which at the northern end is associated a bank of Nummulites. Whether we regard the rock of Gamboa as of 'Tongrian' or 'Aquitanian' age (i.e. Oligocene), it represents the most ancient formation of the Isthmus. Wagner has spoken of Permian grits on the Pacific coast, but these are merely trachytic tuffs and breccias reddened by decomposition. Mr. Hill has endeavoured to assign to these same tuffs a Cretaceous age; we shall see, however, that they are clearly superposed on the rock of Gamboa, and even on Miocene fossiliferous limestones.

The Atlantic Slope.—Taking the breccia and the associated beds with Nummulites as a datum-line, we find in the direction of Colon a series of marine beds more and more recent as we approach the coast. This series, which is perfectly continuous, contains the débris of older eruptive rocks, but without any lava-flows, and extends in time from the 'Aquitanian' to the Lower Miocene. Mr. Dall had previously determined the fossils of some of these beds as Eocene (Claiborne), but their superposition to beds with *Orbitöides* is certain. The *calcaire à Orbitöides* itself, associated with the sandstones and clays of Vamos, are regarded as *Aquitanien marin.* The highest beds on this side, excluding the Quaternary, are the *argiles de Mindi* of Lower Miocene age. The fauna, which is very rich and well preserved, represents that of the Miocene of the Antilles.

South-West Slope: Cutting of Culebra.—Passing to the other side of the central anticline, we find a series of beds almost symmetrical with the preceding, but which differ in containing brackish intercalations with vegètable matter and abundance of eruptive rocks. In the coloured section these are generalized under the heading "Tufs et gres de la Culebra (Aquitanien schisteux et lignitifère)."

The whole of this 'Aquitanian' series is pierced by the 'andesites de la Culebra' of Upper Miocene age, and the peaks of the Cerro Culebra are composed of these same andesites. Above this very extensive and varied series of beds of 'Aquitanian' (i.e. Upper Oligocene) age, there come the equivalents of the Lower Miocene of the Atlantic side, reinforced by beds of trachytic tuffs.

Pacific Slope.—Beyond the great cutting the lignite system falls below sea-level, but the limestone with *Pecten subpleuronectes* represents the same fossiliferous horizon as on the Atlantic side. The trachytic tuffs of the Pacific side are more recent than this, i.e. than the base of the Lower Miocene, an opinion, as we have already seen, opposed to the views of Hill. In speculating as to the formation of the Isthmus generally, the authors especially dwell on the slight consideration which should be attached to the difference between the marine deposits on the Atlantic side and the brackish-water deposits with lignite, leaves, etc., on the other. This they think tends to minimize the importance of the *bombement* since the Oligocene epoch.

Latest Eruptions: Dividing Ridge.—With the formations noticed above the sedimentary series of the Isthmus terminates, but the eruptions have continued since the deposition of the Lower Miocene: these last eruptions in the neighbourhood of the canal constitute the summits of the actual crest. We have already seen that they are described as andesites. It is only possible, say the authors, to fix a lower limit to the age of these rocks; they traverse in dykes the Lower Miocene, to which their flows are superposed. "But what one can say is that *they have no connection* with the recent volcanic series known in Costa Rica, Nicaragua, and Guatemala, a series of which the actual volcanoes are only the enfeebled prolongation. All observers, and especially Mr. Hill, are very explicit on this point. Now the earthquakes of the region are directly connected with volcanic eruptions; it is then an essential point to know that volcanic activity has long since been extinct in the region of Panama."

This account should not terminate without an allusion to the *argiles rouges superficielles*, which are the result of the disintegration of all the above-mentioned formations, both igneous and sedimentary, under atmospheric agencies well known in the tropics. This material occurs on the surface and covers the several formations unconformably. It functions apparently as a kind of drift and is very apt to slide, to the great detriment of the canal cuttings. A description of the Quaternary beds and alluvium follows. From the circumstance that no Pliocene beds are found on the Atlantic coast the authors infer that the sea was more distant at that period than at present. An elaborate microscopic description of the rocks concludes this memoir.

II.

Mons. Bertrand alone is responsible for the second memoir, which is illustrated by a map of the volcanoes of Central America after Mons. Sapper (Zeitschr. deutsch. Gesellschaft, 1897), and also by another map, showing the lines of folding and the lines of volcanoes in Central America. In describing the four great volcanic ranges, viz., those of Guatemala, San Salvador, Nicaragua, and Costa Rica, the author observes that these are arranged in echelon, and he is careful to indicate that the points of fracture of each of the volcanic series correspond to the lines of exceptional mobility which are marked by the existence of a lake or equivalent depression. The lake of Nicaragua is one of these, and he observes that if volcanic activity has opened out the way for the piercing of the canal such an agent must be regarded as a formidable auxiliary. He goes on to describe in considerable detail the function of these fractures, which are transverse to the general alignment of the several volcanic ranges, and insists upon it that the four fractures of the first class, viz. those which effect the dislocation of each of the four volcanic ranges, mark the sites of the greatest instability.

The author has no doubt as to the correctness of the above generalization, but there are further conclusions of considerable interest, though not so absolutely certain. The volcanic activity of this region appears to be undergoing a change of position, and this too in a definite direction. He quotes Suess in support of this view, who considered that this shifting of position is always taking place in the direction of the Pacific. After going into the history of eruptions and earthquakes, he concludes that in the course of a few centuries since the Spanish conquest "the preponderance has passed from Guatemala to San Salvador; and, as to Nicaragua, the difference with the aforementioned states is growing less. If we add that in Mexico volcanic activity has immensely diminished since the Quaternary period, that in the preceding periods it attained its maximum much further north, along the coasts of the United States of America, we cannot fail to be most strongly struck by the significance of the preceding enumerations." If we proceed to apply this principle of shifting to the great transverse faults, which break the continuity of the volcanic chains, we perceive the same movement *en échelon* from north-west to south-east. "The transverse fracture of Guatemala has but one active volcano in its neighbourhood, viz. Fuego: it is a seismic line of diminishing intensity; its lake has scarcely a volcanic appearance; it is a fire-place on the road to extinction. Fonseca, with its girdle of active volcanoes, has had its great catastrophe in 1835: whether or no that is likely to be the last, it is a fire-place in full activity. The lake of Nicaragua is also an active fire-place; it is perhaps, as Fuchs asserts, the principal fire-place in Nicaragua; but, violent though it has been, the eruption of 1883, compared with that of Coseguina, is but an abortive eruption. *It is a warning; the catastrophe has yet to come.*"

With such a possibility in view Professor Bertrand asserts that the dangers which menace this region are by no means of a vague nature. Again, he insists that the line of Nicaragua is one of the lines of weakness and instability of Central America, the lowering of the platform being due to a transverse volcanic fracture; the same cause which creates apparent facilities for the cutting of the canal creates also a lasting danger. What has happened on the homologous site of Fonseca indicates the nature of this danger, not with absolute certainty, but with the chance of fulfilment at no distant period. He then proceeds to point out the possible results on works such as an interoceanic canal would require. What with eruptions, earthquake shocks, and seismic waves, these would have a poor time of it, and he reminds his readers that during the earthquake of May, 1844, the waters of Lake Nicaragua rose and caused tremendous damage along its shores. Hence he issues a warning against the folly of entering into a hopeless contest with the forces of Nature.

Reverting once more to the Isthmus of Panama, Professor Bertrand points out that in the whole of the region included between Chiriqui, whose last eruption was in the sixteenth century, and Tolima, the most northern volcano of the Andean system, there are no recent volcanoes: it is a region of calm between the two Americas. As we have already seen, the latest eruptions date from the end of the Miocene period. The lowering of the platform at Panama is due, not to a transverse fracture, but to a lesser manifestation of the forces which have caused the Isthmus to rise up. "The Isthmus," he says, "is formed by an extremely flattened vault, showing in the centre flows and breccias of Oligocene age, on which repose on either side, with a slight inclination, the series of Aquitanian and Miocene beds. The eruptions, for the most part submarine, have continued intermittently to the end of the Miocene; then came the uplift, before the Pliocene, which has formed the central anticlinal of the Isthmus. This anticlinal is most conspicuous from north-west to south-east, consequently it has made its mark more strongly in the contour of the country." This is the sole cause of the natural gap of Panama. He further entertains the question of earthquakes in this district, which, when compared with those of other places in Central America, seem to be unimportant. The question of the subsidence of the Bay of Panama is discussed in connection with the hypothesis of Suess of a progressive subsidence of the Pacific coast. He concludes that there really has been a subsidence, so far as the Bay of Panama is concerned, but he does not see any indication that the phenomenon is likely to continue.

The concluding part of this memoir deals with the great structural lines of Central America and of the Caribbean Sea, including also the adjacent portion of the South American continent. In this the author to a certain extent reflects the views of Suess. It is a question of high tectonics, which has only an indirect bearing on the comparative merits of the Panama and Nicaragua routes. The author supplies his readers with a very useful sketch-map, a perusal of which will enable them to follow his views. The main conclusion with which we are concerned is the establishment of a hypothetical line which he calls an *arête de rebroussement.* This, he says, is the true line of division between North America, including the Caribbean Sea, and South America; its results, as regards volcanoes and earthquakes, have the effect of producing a region of calms, a sort of *dead angle,* where Panama has the good fortune to be situated at about an equal distance from two dangerous lines.

The following are his conclusions:—

There are no volcanoes around Panama, all eruption having ceased since the Miocene: this is the first point and the most important of all.

With the exception of the earthquake of 1621, which is even contested, there have never been in the region anything but slight shocks, of which a portion are due to the 'echo' of earthquakes at a distance.

The depression utilized by the scheme of the Panama Canal is not a transverse fracture.

The depression of the Pacific coast, and especially the sinking in of the Bay of Panama, in favour of which view there are numerous indications, should not be regarded as phenomena in the course of operation, but as phenomena actually effected, at any rate as regards the actual geological period. In this there is no special cause for mobility of the soil.

Lastly, the position of the lines of folding, and the distribution, according to these lines, of volcanic or seismic activity, show that Panama is situated in a kind of dead angle, in a tranquil zone, at an equal distance to the north and south of the last lines of disturbance.

Thus, all these considerations, whether we regard them from a statistical, a volcanic, or a tectonic point of view, lead to the same result; they allow us to conclude that Panama is the most stable and the least threatened region of Central America. W. H. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

June 18th, 1902.—Professor Charles Lapworth, LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Great Saint-Lawrence-Champlain-Appalachian Fault of America, and some of the Geological Problems connected with it." By Henry M. Ami, M.A., D.Sc., F.G.S.

The extent, earth-movements, and striking characteristics of this fault-line and of the geological formations which occur along this line of weakness in the earth's crust, with special reference to the formations in British North America, were discussed.

Recent investigations in the succession of faunas and geological formations in Eastern Canada have emphasized the fact that those formations which occur to the south and south-east of this great dislocation are strikingly like the geological formations referable to the same geological systems in Great Britain and Western Europe. The fault, as it is traced to-day, appears to divide the geological formations of the Maritime Provinces and Canada into two distinct geological provinces—one, east of the fault, in which the several formations resemble both lithologically and palæontologically the British succession; the other, to the west of this great fault, where there occurs the typical American or epicontinental type of succession.

2. "The Point-de-Galle Group (Ceylon): Wollastonite-Scapolite-Gneisses." By Ananda K. Coomáraswámy, Esq., B.Sc., F.L.S., F.G.S.

The chief rock-types vary from basic pyroxene-sphene-scapolite-rock, through intermediate rocks composed of pyroxene, scapolite, and wollastonite, with felspar and quartz subordinate or abundant, to acid types made up of orthoclase-microperthite or coarse-grained quartzo-felspathic rocks. They differ from the normal types belonging to the Charnockite Series in their somewhat coarser grain, in the presence of wollastonite, scapolite, and sphene, the existence of definite dykes and segregation-veins crossing the foliation, and in the absence of garnet, hypersthene, original mica, and hornblende; but they resemble the series in the variability of chemical and mineralogical composition, in the conspicuous foliation, the common strike, the petrological character of the acid types, and in the local tendency to graphic structures. The foliation, dykes, weathering, and relationship to the Charnockite Series are described: and an account is given of the more important of the minerals. The rocks must be classed as orthogneisses, and the wollastonite and scapolite are original minerals. Possibly the richness in lime is due to the absorption of a mass of limestone by a portion of the Charnockite Series. If this be the case, the lime-silicates must be regarded as endomorphic contact-minerals. On the other hand, the local richness in lime might be due to an original variation in the constitution of the magma. The rocks show a progressive differentiation from basic to acid types, the coarse segregation-veins being the last product of the process. That the rocks have not suffered from earth-movement since their complete consolidation is evidenced by their microscopic characters, while the interlocking of the minerals at the junction of the segregation-veins with the matrix shows that the veins are of contemporaneous character.

3. "On the Jurassic Strata cut through by the South Wales Direct Line between Filton and Wootton Bassett." By Professor Sidney Hugh Reynolds, M.A., F.G.S., and Arthur Vaughan, Esq., B.A., B.Sc., F.G.S.

In this section a thin bed of typical Cotham Marble is followed by the 'White Lias,' and that by the Lower Lias, which in this district attains a thickness of about 200 feet. The following zones are represented: (1) the *Planorbis*-beds, containing the *Ostrea*-beds and the *Cidaris*-shales; (2) the *Angulatus*-beds, including the *Conybeari* sub-zone; (3) probably the *Bucklandi*-bed; (4) the *Turneri*-shales; (5) the *Oxynotus*-beds; (6) the *Armatus* and *Jamesoni*-beds; and (7) the *Capricornus*-zone. The strata are remarkably shaly, limestone being predominant only at the base. The typical ironshot Marlstone is only a few feet thick, and the Upper Lias is reduced to a thickness of about 10 feet. The latter consists of a compact, cream-coloured marl with *Ammonites falcifer*, a compact marly limestone with *Amm. communis*, and a pyritic bed containing *Amm. bifrons*. The Cotteswold Sands are 185 feet thick, and contain, at several horizons, hard marly beds with *Amm. striatulus*. They are capped by the Cephalopod Bed, in which Mr. S. S. Buckman has recognized four Ammonite-zones.

The Inferior Oolite has at its base a rock on the horizon of the 'Pea-Grit' followed by Oolitic limestones and '*Trigonia*-Grit.' It is succeeded by an Oolitic limestone of considerable thickness containing fossils of the Fullers' Earth type, and forming a passage between the Inferior Oolite and the Fullers' Earth, which comes next in succession. Above this are sandy limestones, passage-beds, with *Amm. gracilis*, a form found in the Stonesfield 'Slate.' The Great Oolite consists of white Oolitic limestones with a *Pholadomya*-bed below, and an upper series of wedge-bedded Oolitic limestones containing lenticular patches of clay and sand with a Bradford Clay fauna. The Forest Marble, which is of great thickness and monotonous character, consists chiefly of shales, with bands of sandy, shelly, and Oolitic limestones. It is followed by the Cornbrash. The Oxford Clay with the usual zones, and the Corallian clays and pisolite close the sections. Fossil lists and palæontological notes on each subdivision are given.

The next meeting of the Society will be held on Wednesday, November 5th, 1902.

CORRESPONDENCE.

NOTE ON A NEARLY COMPLETE SPECIMEN OF *ICHTHYOSAURUS THYREOSPONDYLUS* FROM THE KIMERIDGE CLAY OF SPEETON.

Sir,—It will be well to put on record a recent find of this uncommon species, especially as the remains now discovered are more complete than any previously recorded, and largely increase our knowledge of the osteology of this animal. While examining some recent exposures to the north of the Speeton "Middle Cliff," Mr. C. G. Danford, of Reighton, detected some vertebrate remains. He was successful in the course of several days in excavating 53 vertebræ, a large number of ribs, the lower jaw, and portions of paddles, all clearly belonging to one individual. Dr. Smith Woodward has identified the remains as those of *Ichthyosaurus thyreospondylus*, Owen, and associated fossils confirm the age to be Kimeridgian. The vertebræ of this species were figured by Phillips in his "Geology of Oxford," 1871, and, so far as I can find, no other portions of the skeleton were known until the discovery of the present specimen. Yorkshire is also a new locality for the species.

Mr. Danford has generously placed the specimen in the Hull Municipal Museum. This Museum, which is now Corporation property, has as a nucleus the collections of the old Literary and Philosophical Society, and as at present an attempt is being made to get together a typical local collection of fossils, the gift of this skeleton is a most opportune one.

The only other important remains of sauria from the Kimeridge Clay of Yorkshire were found in a brick-pit near South Cave many years ago, and consist of two large paddle-bones, some vertebræ, etc. These also the Hull Museum has been fortunate enough to secure, through the generosity of Mr. G. W. B. Macturk.

Thos. Sheppard, F.G.S.

Hull Museum.

THE RIVERS OF WALES.

Sir,—May I be permitted to assure Mr. Strahan that it is not his criticisms to which I object, even though he still finds the second part of my paper too great a tax upon his credulity. What really concerns me, as a worker in the Principality, is, that the Quarterly Journal of the Geological Society should be open to speculation about the rivers of South Wales and closed to speculation about those of North Wales. Philip Lake.

August 8, 1902.

LITTORAL DRIFT.

Sir,—My friend Mr. W. H. Wheeler's new book on the Sea-Coast has been reviewed with such universal commendation that it may seem invidious to offer any word of criticism. But, as my own work in the same direction was reviewed in the Geological Magazine some years ago, and as if Mr. Wheeler is right I am most undoubtedly wrong, it may be as well to point out briefly my reasons for divergence, leaving it to experts to decide the questions at issue.

Mr. Wheeler's conclusions are based, explicitly or implicitly, on some six hypotheses, viz.:—

(1) That the tidal wave is a wave of translation.

(2) That the flood-tide current generally, as a current, is a stronger current than the ebb-tide current.

(3) That the flood-tide current generates tidal wavelets of translation.

(4) That sea waves on approaching the shore become waves of translation.

(5) That sea waves approaching the shore raise the mean level of the water, with the effect of adding temporarily to the volume of water above mean level, as compared with the volume below that level.

(6) That the proportion of height to length of wave may be as much as 1 to 3.

Mr. Wheeler incidentally discusses a wave with the assumed proportions of 30 feet long and 10 feet high.

It would be scarcely possible to discuss the evidence, mathematical, observational, and experimental, on these six points, under some two or three hundred pages.

In this as in many other cases controversialists do not use the same terms with the same meanings, so that the nomenclature must first be cleared, e.g.:—

(1) The tidal wave, due to the attraction of moon and sun, gives rise to two currents, an ebb and a flood; but, when the flood runs up a channel such as the Severn, and creates a 'bore,' observers are apt to speak of such bore as the tidal wave itself, instead of as a subsidiary wave due to the retardation of the tidal flow-current in the river.

(2) As the flood-tide current at sea runs, as a rule, three or more hours after high-water, the term 'flood tide' is ambiguous.

Sir George Airy observes that, "in the tide wave and every other wave which travels along a channel . . . . this law is universal, that the water is travelling forward with its greatest speed at the time of high water, or at the top of the wave" ("Tides and Waves," art. 183). The flood-tide current usually flows from 'half flood' to 'half ebb'; and the ebb current ebbs from half ebb to half flood. Thus, when Mr. Wheeler discusses the effect of the flood-tide current it is most important to know exactly what is meant; for the water does not turn in direction until the tide has been rising some three hours, unless affected by special circumstances.

(3) Then there is another important source of confusion of ideas among writers generally. The great tidal wave is often spoken of as though a wave which, crossing the Atlantic, impinges on the coasts of Europe; whereas of course the motion of the great tidal wave is away from the British shores, travelling from east to west. Thus no little confusion arises between the ideas of the great tidal wave and the tidal currents which run in an out of our British waterways. The generation of tidal wavelets of translation by the flood-tide current, or any tidal current, is not in accordance with my own experience at the seaside during the past fifty years.

(4 and 5) These hypotheses are not confirmed either by my own observations or experiments.

(6) A proportion of wave length to height of only 3 to 1 is to myself inconceivable. My boat was 26 feet long with a freeboard of about 2 feet. I should not be writing this letter if one were liable to encounter such waves or anything approaching them in the English Channel. I should say that a length to height of 20 to 1 would be very excessive; and that 40 to 1 would be much nearer the mark. My friend Mr. Howard Fox, F.G.S., has himself observed waves with a period of twenty seconds at the Lizard Signal Station. These waves would be just over 2,000 feet long. Sir G. G. Stokes records waves with a period of 17 seconds.

It is true that Littoral Drift has a limited interest for geologists; but the action of waves on the coast, and on sea-bottoms to at least a depth of 100 fathoms, affords geological and palæontological problems of very great interest indeed, so that it is advisable to see that the foundations are securely laid.

If any mathematician who can speak with authority would write a little primer on wave-action, similar to Sir Archibald Geikie's shilling Primer of Geology, it would be invaluable. For my own instruction, when working and experimenting, I was entirely dependent on the kindness of Lord Rayleigh, who was ever ready to explain what I failed to understand; and of Sir G. G. Stokes, who worked out a special case for me, since published in the Transactions of the Devonshire Association.[1] But, so far as my experience goes, the information generally accessible to non-mathematicians is, on this subject, worse than useless, being almost invariably misleading.

[1] Trans. Devonshire Assoc., 1887, p. 512.

Of course, I accept implicitly all Mr. Wheeler's own observations; but, as I demur to the aforesaid six hypotheses, I am unable to accept his explanations. A. R. HUNT.

SOUTHWOOD, TORQUAY.
July 17, 1902.

LAKES OF SNOWDONIA.

SIR,—In the GEOLOGICAL MAGAZINE for 1900 (Dec. IV, Vol. VII, p. 58) Mr. Dakyns criticizes a paper published in a previous volume of the Magazine, in which Mr. Adie and I treat of the Lakes of Snowdonia. Mr. Dakyns has convicted me of two mistakes, one in a matter of observation, the other in the manner of expression of a statement. For each of these mistakes I am alone responsible.

I had hoped to accept Mr. Dakyns' polite invitation to go over the ground with him, but various circumstances have prevented me from doing so, and I have therefore awaited the publication of Mr. Jehu's paper upon the Lakes of Snowdonia (Trans. Roy. Soc. Edinb., vol. ix, p. 419) before making my confession of error.

Mr. Jehu informs me that I undoubtedly mistook an artificial diversion of the stream issuing from Glaslyn for a natural one. As he has not corrected this serious error in a prominent manner in his paper, I feel bound to do so. I can only plead in mitigation of my offence that the outlet was examined towards dusk on a sunny day in the Easter vacation; nevertheless, as our paper was partly occupied with criticism of the views of others, I feel that I ought to have revisited the lake before making my statement.

The other matter refers to the bed of the Colwyn, which I said "runs over drift." I should have said that drift extends along the lower part of the valley beneath or near the bed of the river.

Concerning other parts of Mr. Dakyns' paper I may have something to say in the future, but I feel that no further time should be allowed to elapse before acknowledging mistakes to which attention has been drawn in so straightforward a manner. JOHN E. MARR.

CAMBRIDGE, *August*, 1902.

OBITUARY.

PHILIP JAMES RUFFORD, F.G.S.,

OF THE HASTINGS AND ST. LEONARDS MUSEUM ASSOCIATION.

BORN JANUARY 26, 1852. DIED JUNE 19, 1902.

IT is with deep regret we record the death of Mr. Philip Rufford, F.G.S., of 37, Magdalen Road, St. Leonards-on-Sea, a most ardent geologist and enthusiastic naturalist, who had for some years devoted himself very earnestly to the advancement of the Hastings and St. Leonards Museum forming a part of the Brassey Institute, Hastings, in which he spent a considerable portion of his time.

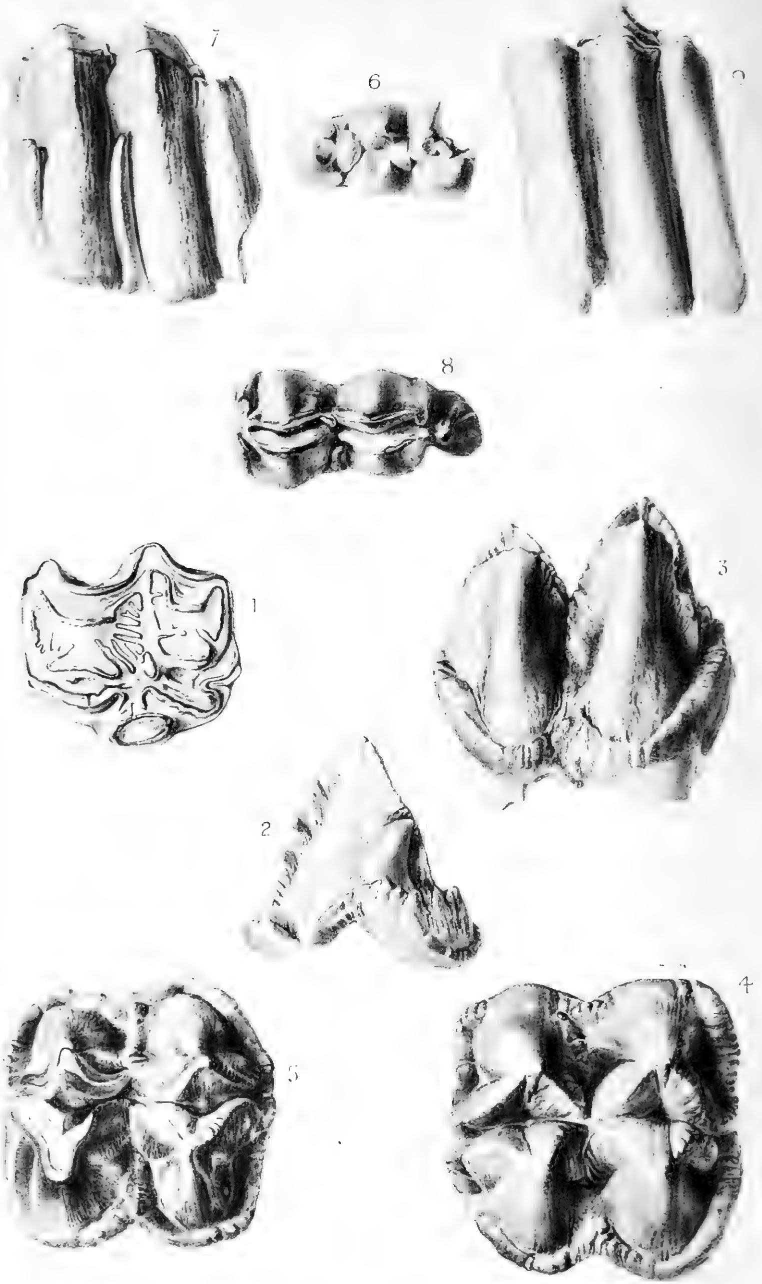
Philip James Rufford, the only son of the late Rev. Philip Rufford, M.A., Rector of Thorne-Coffin, Somerset, was born at Great Alne,

Ruffordia Goepperti (Seward), a new fossil fern from the Wealden Formation, Ecclesbourne, Hastings, discovered by Mr. Philip J. Rufford, F.G.S.

[See Mr. A. C. Seward's Catalogue of Wealden Plants in the British Museum (Nat. Hist.), Part I, pp. 75–86, pl. iv, 1894.]

Warwickshire, January 26th, 1852. He was brought up as a Civil Engineer, but early in his career his health broke down and he was compelled to abandon his profession, and about the year 1888 he settled with his mother in The Croft at Hastings. Having by careful study and observation previously acquired a very considerable knowledge of geology, on coming to reside in Hastings he devoted all his time and attention to collecting fossils from the Wealden strata of the neighbourhood, especially at Ecclesbourne and Fairlight. Mr. Rufford's favourite collecting-ground was along the sea-shore from Rock-a-Nore to Cliffs End. He was fortunate in obtaining a very fine collection of Wealden plants, which he disposed of at a nominal valuation to the British Museum (Natural History), Cromwell Road, only stipulating that they should, as soon as possible, be figured and described by the Museum. This task was ably undertaken by Mr. A. C. Seward, M.A., F.R.S., in 1893–4 and 5. In the preface to vol. i the Keeper of Geology writes: "We are fortunate in possessing many of Mantell's original specimens of Wealden plants, but, although historically of great interest, they are largely superseded by those recently obtained by Mr. P. Rufford, whose fine collection has lately been acquired for the National Museum" (p. vi op. cit.). In the same volume Mr. Seward describes 147 specimens, mostly Pteridophyta, from Mr. Rufford's collection. Amongst these is a new genus of ferns dedicated to the discoverer, by Mr. A. C. Seward, as *Ruffordia*, gen. nov. (p. 75, pl. iv), having a finely divided form of frond, not unlike *Asplenium fragrans*, Sby., in habit. In vol. ii Mr. Seward illustrates the *Cycadites* and *Zamites* (with their fruits and stems), and the Coniferæ, and refers to no fewer than 196 specimens from Mr. Rufford's collection, many of which he describes and figures. This interesting series of Wealden plants is now all well arranged and exhibited in Gallery No. X, Department of Geology, British Museum (Natural History). The ferns and zamia-leaves from Ecclesbourne are very beautiful, and form a most attractive part of the collection.

The Museum of the Brassey Institute commenced to assume an organized and definite shape in 1891, when the Committee purchased a part of the Beckles Collection of Wealden and other fossils. Mr. Rufford, who was then a member of its Committee, took upon himself the arduous task of selecting, naming, and arranging these objects with his own hands, adding largely to the geological section of the Museum from his own private cabinet. He also contributed a series of Recent marine, land, and fresh-water Mollusca, Recent Sponges, Hydroids, Echinoderms, Polyzoa, etc. Owing to ill-health he last year visited Italy and stayed the winter in Rome. Early in the spring he spent some weeks in Naples, where he was much gratified by the kindness he received from Dr. Anton Dohrn, Director of the Marine Zoological Station, and from his assistants, in his efforts to gain some knowledge of the living sea fauna for furthering his studies at Hastings. His loss to the Museum will long be felt by all his colleagues who served with him on the Committee.



G. M. Woodward, del.

Pliocene Mammals from Egypt.

THE

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No. X.—OCTOBER, 1902.

ORIGINAL ARTICLES.

I.—Note on a Pliocene Vertebrate Fauna from the Wadi-Natrun, Egypt.

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

(PLATE XXI.)

AMONG the collections received from the Egyptian Survey for determination is a number of vertebrate remains, chiefly mammalian, from the Wadi-Natrun, whence they were obtained by Captain Lyons, the Director-General of the Survey, and by Messrs. Beadnell and Blanckenhorn, members of his staff. Last year, on my return from Mogara with Mr. T. Barron, I was able to collect for a few hours on the hill called Gart-el-Moluk, from which most of these fossils were obtained, and found a few additional fragments. Finally, Dr. Studer, of the Berne Museum, has very kindly lent me the collection he received from the same locality, and has himself described in some detail.[1] I believe, therefore, that a great part of the specimens from this locality are now in my hands. Unfortunately in most cases the remains are in a very fragmentary condition and little can be made of them, but there are a few well-preserved teeth and limb bones which indicate the existence of a fauna of considerable interest, and are sufficient to show that the locality will probably yield good results to a systematic search. At present the collections include remains of a small *Hippopotamus*, a *Hipparion*, a small pig-like animal, and various Antelopes. In the present note I propose to give a short account of the more important of these specimens.

Hipparion. (Pl. XXI, Fig. 1.)

Hipparion is represented in the collection by a very well-preserved left upper premolar (?p.m. 4). The enamel is extremely complexly folded, and in this respect the tooth closely resembles that of

[1] "Ueber fossile Knochen vom Wadi-Natrun, Unteregypten": Mittheil. d. Naturforsch. Gesellschaft in Bern, 1898 (1899), p. 72.

Hipparion gracile Kaup, from the Pliocene of Epplesheim. It differs, however, from most specimens of that species in having its inner column more laterally compressed. In the form of the inner column *Hipparion Theobaldi*, from the Siwalik Hills, approaches the Egyptian form very nearly, some of the teeth figured[1] by Mr. Lydekker being almost identical in structure with the specimen here described. In the absence of more complete material it will be best to refer our specimen to the widely spread species *Hipparion gracile*, at the same time drawing attention to the fact that in some respects it resembles *H. Theobaldi*, and, like it, probably represents a somewhat later stage in the evolution of the group, the form of the inner column being rather more like that of *Equus* than is the case in the European species.

The tooth from Wadi-Halfa described by Lydekker (Quart. Journ. Geol. Soc., vol. xliii, 1887, p. 161) is that of a true *Equus*, near *E. sivalensis*, and the deposits from which it came are probably Upper Pliocene or early Pleistocene age.

The dimensions of the tooth now described are: length 29, width 28, height of crown 38 mm.

Hippopotamus hipponensis, Gaudry. (Pl. XXI, Figs. 2–5.)

Among the best preserved specimens are three teeth of a small *Hippopotamus*, which, for reasons given below, may be referred provisionally to the above-named species. The specimens are, a lower premolar, probably p.m. 3 (Pl. XXI, Fig. 2), and two upper posterior molars (Figs. 3–5), one of which is quite unworn.

The species *H. hipponensis* was founded by Gaudry[2] on teeth occurring in Pliocene beds near Bone in Algeria. The premolar is stated to be especially characterized by a very prominent postero-internal cusp. The molars are not figured, but it is stated that they do not present any important peculiarities. From this it would appear that the sides of the columns were probably grooved so as to give a trefoil pattern in wear, for the absence of such a marked characteristic of most *Hippopotamus* molars could not well have escaped Professor Gaudry's notice. For this reason it seems probable that the teeth from the Pliocene of Casino, described and figured by Pantanelli[3] as those of *H. hipponensis*, may in fact belong to another and probably earlier species, since in them the trefoil pattern is wanting, or, at least, obscure. The animal which Pomel[4] refers to *H. hipponensis*, without giving any valid reasons for his determination, seems to be quite different and is of Pleistocene age.

For the present it will suffice to refer the specimens to Gaudry's species, and defer more detailed consideration until further material is available.

[1] Lydekker, "Siwalik and Narbada Equidæ": Mém. Geol. Surv. India, Palæontologia Indica, ser. x, vol. ii, pt. 3 (1882), pl. xiii, fig. 1.

[2] Bull. Soc. Géol. France, ser. III, vol. iv (1876), p. 501, pl. xviii.

[3] Pantanelli, "Sugli strati Miocenici del Casino (Siena)": Mem. R. Accad. Lincei (3), vol. iii, p. 309, pl. iv, figs. 1–7 (1879).

[4] Pomel, "Carte Géologique de l'Afrique — Paléontologie": Monographie No. 8, Les Hippopotames, p. 9; Algiers, 1896.

The premolar is extremely like that figured by Gaudry in the paper referred to. The form of the cingulum and of the postero-internal cusp, as well as the sculpture of the enamel, are almost identical. In these points also some premolars of *H. sivalensis* are very like our specimen, and in *H. liberiensis* this prominent postero-internal cusp is regularly developed on the lower premolars. The form of this tooth is well shown in Fig. 2. It is much larger than the corresponding tooth in *H. liberiensis*, and is about the same size as some specimens of the premolars of *H. sivalensis*. Its width is 19 mm., its length 32 mm.

Of the two upper molars, one (m. 3) is quite unworn. This specimen is shown in Figs. 3 and 4. The cingulum is very well developed, particularly on the anterior border, and at either end of the transverse valleys there are a number of tubercles which seem also to belong to the cingulum. The anterior pair of cusps are higher than the posterior, and the inner stand slightly above the outer. The sides of the columns are pinched in by vertical grooves on their anterior and posterior faces (see Figs. 3, 4, and 5), so that each column shows the usual trefoil pattern as soon as wear has removed the summit. In this these teeth differ from those figured by Pantanelli, and also from those of *H. liberiensis*, in which the trefoil is imperfectly developed. The teeth, moreover, are more brachydont than those of *H. amphibius* or *H. liberiensis*, i.e. the height of the cusps is rather less in proportion to the other dimensions of the teeth than in those species, and the longitudinal valley is rather deeper. The enamel is thickly sculptured by a series of more or less vertical grooves, and there is also a very fine horizontal striation, best shown on the cingulum and near the base of the crown (see Fig. 3).

The other molar (m. 2, Fig. 5) belonged to a somewhat smaller individual. The cingulum is strongly developed all round and sends spurs into the openings of the transverse valley. Wear has commenced, and is most marked on the antero-internal cusp; the pattern is shown in Fig. 5, where it will be seen that indications of the trefoil pattern are already noticeable. Wear is also well marked on the inner faces of the transverse valley, the cusps of the lower molar having worked between those of the upper. In this tooth also the slightly more brachydont condition is apparent.

The dimensions of the teeth figured are :—

	Length.	Width.	Approx. height of crown.
p.m. 3	32 mm.	19 mm.	31 mm.
m. 2	36 ,,	35 ,,	27 ,,
m. 3	39 ,,	39 ,,	33 ,,

A number of limb bones referable to *Hippopotamus* have been determined by Dr. Studer (*op. cit. supra*). One of these specimens is a small humerus (see figure in text) which no doubt belongs to the present species. It is very closely similar to the humerus of *H. sivalensis*, with which I have compared it, but at the same time is somewhat smaller. The presence of an irregular perforation in the floor of the olecranon fossa seems to be of little importance, and may be the result of accident. The form of the *condylus internus* is like that of the Indian species. The width of the distal end of this specimen is 97 mm.; the width of the lower end of the shaft is 40 mm. The proximal end of the conjoined radius and ulna and the distal end of the ulna and part of the radius likewise differ from the corresponding parts in *H. sivalensis* in little besides their somewhat smaller size.

Distal half of humerus of *Hippopotamus hipponensis*, Gaudry. $\frac{1}{3}$ nat. size.

The femur (see Studer, *op. cit.*, p. 75) differs from other *Hippopotamus* femora with which it has been compared in having a shorter neck, so that the rounded head is less pedunculate than is usual in the genus. This bone seems to have belonged to a larger individual than most of the others.

There are two calcanea in the collection which, though worn and broken, are certainly those of a *Hippopotamus*. One of these specimens is much larger than the other, and, like the femur above mentioned, may indicate either that the range of individual variation in size was very considerable or that there was a second species; the second alternative seems the less probable; the length of the larger is approximately 16·5 mm. A phalangeal bone is rather more slender than in other species of *Hippopotamus*. Its length is 60 mm., the width of its proximal end is 34 mm., the height of ditto 25 mm.

Sus, sp. (Pl. XXI, Fig. 6.)

The third lower molar of a small pig seems to be the only fragment of that animal found in the collection. The form of this specimen, which belongs to the right side, is shown natural size in Fig. 6. It will be seen that it is a simple type of tooth with few accessory cusps and a short talon; the front of the tooth is incomplete, the antero-internal cusp having been broken away; the antero-external cusp is oval in outline. Behind the anterior pair of main cusps and closely adherent to the inner one is a small tubercle (the hinder tubercle of the anterior crescent), and immediately behind this a rather larger tubercle occupying the middle of the transverse valley (this is the 'central-hügel' of Stehlin and the tubercle marked 'e' by Lydekker). Of the hinder pair of main cusps the inner is the smaller and the higher; behind them, again, is a large median cusp (the 'verbindungs-hügel' of Stehlin,[1] 'a' of Lydekker's[2] figures). The talon is short and simple, consisting of a main cusp ('b' of Lydekker) nearly in the middle line, a smaller one ('c' of Lydekker) internal to this, and smaller tubercles opposite the outer ends of the 'verbindungs-hügel': these last small cusps seem to belong to the cingulum, which is not otherwise represented.

The most notable character of this tooth is its very small size. Its length at the base of the crown is 24 mm., at the summit of the crown 22 mm.; its greatest width was approximately 13 mm. It is therefore longer than the corresponding tooth of *Sus punjabiensis* (16 mm.), and at the same time considerably smaller than some specimens in the British Museum referred to *Sus hysudricus*, which in many respects it resembles closely. As Stehlin has pointed out, however, it is very doubtful whether all the specimens referred to *S. hysudricus* really belong to one species; it is the *Potamochœrus*-like form figured by Lydekker (*op. cit. supra*, pl. viii, figs. 2 and 3) which comes nearest to our Egyptian species. With such scanty material as is available at present it is impossible to determine definitely the systematic position of this animal, but it seems most likely that it comes somewhere between the earlier *Palæochœrus* and the later *Sus hysudricus*, or perhaps *Potamochœrus*. The dwarf forms *Sus punjabiensis*, *Sanitherium Schlagintweiti*, and *Porcula salviana*, which seem to be closely allied to one another, may also be related, but are still smaller.

Remains of Ruminants are represented by the teeth, horn-cores, and fragments of limb bones of various antelopes.

Hippotragus ? *Cordieri*, De Christol. (Pl. XXI, Figs. 7 and 8.)

The most interesting of these specimens is an unworn left third lower molar. After comparison with the teeth of many antelopes it was found that this tooth agrees almost exactly in pattern with an uncut third lower molar of a young individual of *Hippotragus niger*, but that at the same time the crown is much more brachydont. Thus, in the recent species the length of the tooth to the height of the crown is as 29 to 43, in the fossil the proportion is as 31 to 36.

[1] Stehlin, "Ueber die Geschichte des Suiden-Gebisses": Abhand. Schweiz. Palaeont. Gesellschaft, vol. xxvi (1899), p. 30.

[2] Lydekker, "Siwalik and Narbada Bunodont Suina," pl. viii, etc.: Palæont. Indica, vol. iii (1884).

The difference is even more strongly marked than would appear from the measurements, because in the fossil the columns are thicker than in the recent species, and the whole tooth has a much more massive aspect. The increase in height seems to have affected the anterior portion more than the posterior, the much greater length of the antero-internal accessory column being particularly noticeable. In the fossil the accessory inner columns lying between the anterior and posterior lobe and between the latter and the talon are very small, the posterior one in fact being a mere rudiment; in the recent animal these have increased greatly in size, and their height is much greater, not only absolutely but also relatively as compared with the main columns. The enamel on the inner face of the tooth is more sculptured than in the recent species, being covered with irregular grooves which give it a surface like that common in teeth of the Giraffidæ. The enamel of the outer face is almost smooth.

A last lower molar of an antelope from the Pliocene sands of Montpellier, figured by Gervais (Zool. et Pal. françaises, 2nd ed., 1859, pl. vii, figs. 8, 8*a*), is closely similar to the Wadi-Natrun tooth; it is referred to *Antilope recticornis*, which Gervais regards as synonymous with *A. Cordieri* of De Christol. This animal has also been described by Forsyth Major (Atti Soc. Tosc., vol. i, 1875, p. 231) from the Lower Pliocene of Casino. The fact that this species is referable to *Hippotragus* was pointed out by Sir Victor Brooke in 1873 (Proc. Zool. Soc., p. 551). A species of *Hippotragus* has also been described by Lydekker from the Pliocene of the Siwalik Hills (Palæont. Indica, vol. iv, pt. 1, 1886, p. 10, pl. ii, figs. 4, 4*a*). It is very likely that the Egyptian form, when better known, will turn out to be a distinct species, but it is here referred provisionally to the widely distributed *Hippotragus Cordieri*, De Christol sp. (*H. recticornis*, Marcel de Serres sp.), above noticed.

The collection also includes a greatly worn molar which agrees closely with the upper milk-molars of *Hippotragus*, and may therefore be assigned to the same species. A horn-core in the collection of the Berne Museum probably also belongs here. It is raised on a prominence of the frontal, enclosing a large sinus which extends upwards into the base of the core itself. It is nearly circular in section, but is so much broken that its form and length cannot be clearly made out; it must have been much shorter than in an adult individual of *Hippotragus niger*. This specimen has been described by Professor Studer, who regards it as that of an antelope related to *Oryx*. There are also some fragments of limb bones, including portions of a femur, a tibia, and a metatarsus; the last belonged to a rather smaller animal than *H. niger*.

The other molar of a Ruminant, figured on Pl. XXI, Fig. 9, is a remarkably hypselodont tooth, resembling in many respects that of a modern goat. It is the last lower molar of the left side and is somewhat incomplete, the antero-external column being lost. It is greatly compressed from side to side, the talon in particular being extremely narrow, at least towards its summit. The length of this tooth is 26 mm., its height 41 mm. I have been unable to find any form closely similar to this, but it seems to resemble some hypselodont teeth figured by Rodler & Weithofer ("Die Wiederkauer der Fauna von Maragha," pl. iv, fig. 5: Denkschr. k. Ak. Wissenschaften, Wien, vol. lvii, 1890, p. 770). The animal was no doubt an antelope, and probably a large gazelle-like form. A horn-core which is somewhat laterally compressed, especially on its outer side, probably belongs to this animal. Its curves are like those of some gazelle horns.

The collection also includes remains of crocodiles, *Trionyx* and other Chelonians, and fish.

The stratigraphy of the beds in which these bones were found is described in detail by Blanckenhorn in "Neues zur Geologie und Palaeontologie Aegyptens," pt. iv (Zeitschr. d. Deutsch. geolog. Gesellschaft, 1901, p. 301), to which reference may be made for further information on this point. He regards the beds as Lower Pliocene, which agrees well with the conclusions arrived at from the consideration of the mammalian fauna, the horizon of which is probably a little later than that of Casino, and is, therefore, either late lower or early middle Pliocene.

II.—*Eophrynus* and Allied Carboniferous Arachnida.

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Part I.

Introduction.

For the opportunity to study the interesting Carboniferous Arachnid forming the subject-matter of the following pages, I am indebted to the kindness of Dr. Henry Woodward, F.R.S., who recently placed in my hands for that purpose a very perfect gutta-percha cast, and a good, though less complete one, in plaster, of the original fossil specimen, which was unfortunately not available for examination in its natural form.

The typical species of the genus *Eophrynus* was described and figured from an imperfect specimen by Buckland in 1836. Dr. H. Woodward in 1871 correctly assigned this fossil to the Arachnida. Buckland regarded it as the remains of a coleopterous insect, and named it *Curculioides prestvicii.* The genus *Curculioides* also contained a species named *ansticii*, the systematic position of which is still in doubt.[1]

[1] Four pairs of appendages are represented as attached to the anterior portion of the body, to the front border of which a separate transverse sclerite was apparently articulated. Buckland regarded this sclerite as the head, and the appendages as the antennæ and three pairs of legs of a beetle. No segments are described in connection with the abdomen, but, judging by the figure, this region was furnished with a large circular anal orifice. Scudder (Proc. Amer. Acad. Arts and Sci., vol. xx, 1882, p. 17) provisionally placed this species in the Arachnida, near *Architarbus.* I suggest that it may be an Arachnid allied to the recent *Cryptostemma.* In the latter the large circular and gaping anus is a very marked feature; there is a movable sclerite jointed to the anterior border of the carapace and completely concealing the mandibles; the appendages of the second pair are tucked beneath the prosoma when at rest, so that from its dorsal side the animal exhibits only four pairs of limbs. In these three features *Cryptostemma* resembles *Curculioides ansticii.*

Thirty-five years later a second and remarkably perfect specimen of *C. prestvicii*, which set at rest the question of the Arachnidan affinities of the species, was discovered in the clay ironstone of the Dudley Coal-measures. Upon the species represented by this specimen Dr. Woodward based the genus *Eophrynus*, leaving *ansticii* by elimination as the type of *Curculioides*.

Unfortunately, owing to certain errors committed by the artist, the figure and description of the fossil are discrepant in various particulars. In other cases important structural points are obscured by heavy shading. These blemishes in the illustration made the subsequent determination of the true structure and taxonomic position of *Eophrynus* a matter of considerable difficulty. A far more accurate figure was subsequently drawn by Miss G. M. Woodward, under Dr. Woodward's supervision, and printed in the "Guide to the Fossil Invertebrata in the Department of Geology and Palæontology in the British Museum" (Natural History), 1897. I am indebted to Miss Woodward for the care and skill shown in the preparation of the figures accompanying Part II of this article, which were taken partly from my sketches representing my conception of the features exhibited by the fossil. Since the cast of *Eophrynus* is the only representative of this group of Carboniferous Arachnida that I have been able to see, I have been compelled to trust to the accuracy of the figures and descriptions of other authors for information regarding allied forms.

The subject-matter of this essay may be conveniently divided into three sections: (1) The morphology of *Eophrynus*; (2) the classification of *Eophrynus* and its allies; (3) the taxonomic position of the Anthracomarti.

1. The Morphology of *Eophrynus*.

The synonymy of *Eophrynus prestvicii* is as follows:—

Eophrynus prestvicii (Buckl. sp.).

Curculioides prestvicii, Buckland: Bridgw. Treatise Geol. and Mineral., vol. ii (1836), p. 76, pl. 46″, fig. 2 (2nd edition, 1837).

Eophrynus prestvicii, H. Woodw.: Geol. Mag., 1871, pp. 386–388, Pl. XI; and of subsequent authors.

The *carapace* is unsegmented. It is narrowed anteriorly, its posterior width exceeding its length. Its median area from the anterior almost to the posterior border is raised into a broad longitudinal axial elevation, divided superficially into ridges and lobes by transverse and longitudinal grooves. Two transverse constrictions which cross its dorsal surface divide it into three subequal portions—an anterior, a median, and a posterior. The last is laterally crested and impressed mesially and behind by a longitudinal groove, which appears to correspond to the median muscular impression or fovea present upon the carapace in some other orders of Arachnida. The median and anterior portions are divided by two longitudinal grooves into a central and two lateral crests. The central crest of the median portion is the highest point of the carapace. It bears a pair of oval pits. The anterior portion slopes obliquely downwards and forwards to its narrowed but bluntly convex extremity. The elevated areas just described are roughened with coarse, sometimes anastomosing, granules. This elevated portion of the carapace occupies rather more than the median third of its area. Behind and on each side of it the carapace projects horizontally and exhibits a coarse sculpturing of pits and anastomosing ridges. The area behind the elevation is short, and marked with a narrow transverse recurved crest which equals the width of the posterior end of the elevation; the area at the sides is impressed with two grooves passing externally into marginal notches which give rise to the trilobed appearance of this region. The three lobes overlie the basal segments of the second, third, and fourth legs (fourth, fifth, and sixth appendages), the grooves and marginal notches corresponding to the interspaces between them and representing, no doubt, the radiating grooves of the carapace of the Araneæ and Pedipalpi, which are known to be the external indications of the points of attachment of the dorsal muscles uprising from the entosternite. Below the lobes the edge of the carapace appears as a narrow but high ledge which apparently rests upon the coxæ of the appendages. The anterior portion of the carapace at the sides and in front of the median elevation where the first and second pairs of appendages emerge is unfortunately somewhat crushed, and the exact details of its structure are difficult to trace. It is noticeable, however, that there is no evidence of the presence of a frontal sclerite articulated to the fore border of the carapace, such as is found in *Cryptostemma* and is alleged by Haase to be present in *Kreischeria*. Apart from the oval pits above described I can find no trace of any structures resembling eyes, though it is almost certain these organs were present in the living animal, considering the size to which it attained.

The *sternal area* of the prosoma is longer than wide, but considerably wider than that of all existing orders of terrestrial Arachnida with the exception of the Araneæ, Amblypygous Pedipalpi, and Acari. As in the Amblypygi (e.g. Phrynidæ), it was apparently membranous at the sides, but is furnished mesially with an anterior and a posterior sternal plate. The latter is short and narrow, and in the specimen has been displaced from the middle line so as to lie in front of the inner extremity of the coxal segment of the sixth appendage of the left side. The anterior plate, on the contrary, has been thrust over towards the right side of the specimen. It is much broader and longer than the metasternite, and lies between, though not in contact with, the coxal segments of the third, fourth, and fifth pairs of appendages (i.e., the first, second, and third walking-legs). It is somewhat deeply bi-emarginate laterally, the emarginations corresponding to the convexly rounded proximal ends of the coxæ of the fourth and fifth appendages. Its anterior portion is lanceolate, and extends forwards between the coxæ of the appendages of the third pair almost as far as those of the second pair or palpi. No trace of a prosternal plate corresponding to the last-mentioned appendages is discernible.

With regard to the structure and relations of the large sternal plate described above, there is, I think, no possibility of error, so clearly defined is the sclerite. But concerning the smaller and posterior sternal sclerite there is room for doubt. Assuming, as I have assumed, that it is part of the sternal exoskeleton, its distinctness from the anterior plate may be due to fracture and subsequent displacement. But in the specimen before me, it appears as a forwardly directed process from the inner edge of the coxa of the adjacent appendage. Since no corresponding piece, however, is traceable upon the better preserved coxa of the opposite side, I have felt justified in assuming that it is not part of the appendage, but part of the sternal area.

Of the appendages of the first pair (*mandibles, chelicerœ*), that of the left-hand side only is exposed. From the dorsal aspect traces of two segments are to be seen projecting forwards from the anterior end of the carapace, the proximal being noticeably longer than the distal. From the ventral aspect there is visible a skeletal piece which, from its position, appears to underlie the distal segment. It is obliquely truncated in front and pointed behind, the pointed portion being marked with a longitudinal groove which may represent the divisional line between the two prongs of a pincer. The whole structure, however, is too ill-defined to allow of any positive statement on the question. So far as an opinion can be formed, however, it appears to me evident that these appendages more nearly resembled those of Opiliones than those of any other order of terrestrial Arachnida.

The appendages of the second pair (*palpi*) are remarkably long as compared with those of the Opiliones Palpatores, which in a general way they resemble. The femur is as long as that of the third leg, and the tibia, which is very slender and unspined, is almost as long as the femur and twice as long as the slender tarsus, which bears a single claw. The joint between the patella and tibia is indistinctly defined. The basal segments are crushed, but they appear to meet in the middle line in front of the sternal area and to be furnished with a large forwardly directed maxillary lobe.

In the remaining appendages (the four pairs of *legs*) the coxæ are arranged at the sides of the sternal area, exhibiting a slightly radial disposition. Judging by the narrow spaces separating the coxæ on each side from one another, these segments were freely movable, like those of the Araneæ and Amblypygous Pedipalpi. The proximal ends of the coxæ of the first pair are inclined upon the margins of the lanceolate anterior end of the sternum.

Those of the fourth pair are considerably larger than the others, diverge from each other at an angle of 90°, and almost meet in the middle line behind the sternal area. Across the proximal end of each and over the narrow triangular space between them runs a distinct, apparently granular ridge, the significance of which I am unable to interpret.

So far as the rest of the segments are concerned, it is regrettable that the tarsus and protarsus are preserved only in one instance, namely, in the first leg of the left side. The segments are subequal in length, and the tarsus, which is attenuated and unjointed, is tipped with a single claw. The tibia also of this appendage is faintly indicated; and a large part, perhaps the whole of this segment, is preserved on the third leg of the right side and the fourth of the left side. In all cases it appears to be a relatively stout and short segment, but little, if at all, exceeding the patella in length. The patella of the fourth leg is about half as long as the femur; that of the other legs, rather more than half. The femora of the first, second, and third pairs are shorter than the carapace; that of the fourth, which is lightly concave on its post-axial side, longer than the carapace. The trochanters of all the legs, like those of the palpi, are well defined on the ventral side. They are large segments, constricted in their basal half, and evidently capable of very free movement upon the coxæ. The legs progressively increase in length from the first to the fourth pairs. Their dorsal surface is granular, pitted, and frequently longitudinally grooved.

The *opisthosoma* (*abdomen*) anteriorly equals the prosoma in width. It expands posteriorly towards the fifth or sixth somite, is widely rounded along its hinder border, and at its greatest width is almost as broad as long. The lateral portions of the terga are expanded into transversely suboblong, closely fitting laminæ, separated by an apparently membranous joint from the main central portion of the segment. The posterior border of the terga in the hinder half of the dorsal surface becomes gradually more and more recurved from before backwards, the recurvature of the penultimate tergum being so great that the posterior edges of its lateral plates lie nearly parallel to the long axis of the opisthosoma. The terga are covered with coarse granules and tubercles. Apart from the granules and less conspicuous tubercles, each tergum is typically furnished along its posterior border with a transverse row of six large tubercles, four on the central part of the tergum and one on each of the lateral plates. Of the former, two are close to the middle line, the other close to the joint of the lateral plate. In front of the two central tubercles there is a pair of about half their diameter which meet in the middle line, and on the posterior border between the two centrals a much smaller tubercle is present.

As was stated in the original diagnosis, *nine* somites, defined by transverse grooves, are traceable on the dorsal side. The lateral borders of the first are ill-defined, and of the second also on the right-hand side, owing apparently, in part at least, to the up-pushing of the coxa of the sixth appendage. The first, however, although a little longer, seems to be narrower than the second, and shows no evidence of the presence of lateral laminæ. The central and lateral tubercles of its median portion are normally developed.

The second tergal plate exhibits on the left-hand side a fully formed lateral lamina, which apparently projects forwards on each side of the first towards the posterior angles of the carapace. The tubercle on the posterior angle of this lamina corresponds exactly with that on the following terga, but the remaining large tubercles characteristic of the laminæ and of the central portion of these segments are almost undeveloped on the second. A median pair a little larger than the rest that stud its surface, and one on the left-hand side, are all that remain to represent the principal tubercles. The posterior border of the plate, moreover, though marked by a series of granules, is less well defined and more sinuous than that of the other terga. An examination of the plate, in fact, forcibly suggests that it is in process of fusion with that of the third somite. Indeed, were it not for the distinctness of the lateral lamina on the left-hand side, it might be interpreted as the anterior portion of the latter somite. This interpretation, however, leaves unexplained the distinctness of the lamina in question, and of the transverse groove that is continuous with its posterior angle, and traverses the dorsal surface from side to side in a direction parallel with that of the recognized tergal sclerites; also it carries with it the conclusion that the second tergum is of exceptional size, namely, three times as long as the first and twice as long as the third.

On the whole it appears to me that the view here adopted, that nine tergal plates are present on the upper side of the opisthosoma, and that the second is reduced in size and modified by the suppression of its large tubercles, possibly also by partial fusion with the third, is more in keeping with the facts exhibited than the alternative hypothesis that has been already discussed.

This view of the existence of nine visible terga on the dorsal side is opposed to that of Haase, Stur, and Ammon, who recognize only eight such plates in certain allied Carboniferous Arachnids they have examined. In the case of *Eophrynus salmi*, Stur declares the dorsal side to be divided by seven sulci into eight plates. His drawing, however, of the anterior portion of the opisthosoma in his species is by no means conclusive on this point. In the first place, there is a want of definition about this area, due, perhaps, to the bad state of preservation of the fossil; in the second place, there is obviously space enough between what are described as the first and second terga for the presence of another plate; in the third place, on the left-hand side nine large segmentally arranged tubercles are represented, whereas, if only eight terga are present, only eight tubercles should be shown.

So, too, with *Anthracomartus palatinus* of Ammon.[1] Eight tergal plates are described. The first is represented as a short plate, as wide as the carapace, laterally attenuated, without laminæ, and fitting into the emarginate anterior border of the second. The latter is large, and its laminæ extend forwards on each side of the first, almost reaching the posterior angles of the carapace; but it is most clearly marked with a transverse and procurved sulcus, defining an area of about the same width and nearly the same size and shape as the first tergal plate. This, I suspect, represents the genuine

[1] Geogn. Jahresf., 1900, pp. 1–4, figs. 1–3.

second tergal plate, perhaps partially or completely fused with the third. If this be so, there will be nine tergal sclerites visible on the upper side of the opisthosoma, at all events in this species of *Anthracomartus*.

Haase's[1] figure of the segmentation of the dorsal side of the opisthosoma of *A. völkelianus* is open to the same interpretation. A distinct, though short and narrow plate is represented between the posterior border of the prosoma and the lightly emarginate anterior border of what he regarded as the first tergite of the opisthosoma. If this hitherto disregarded sclerite be counted as the first, the opisthosoma of the specimen in question presents nine visible terga when regarded from above. This view of the matter reconciles certain differences in the structure of the anterior segments of the opisthosoma in *A. völkelianus* and *A. palatinus*, which the older hypothesis left unexplained.

In the case of *Kreischeria*, again, Haase and Geinitz depict and describe eight terga, and there are only eight rows of tubercles. But between the posterior border of the carapace and what is regarded as the first tergum a narrow sinuous area is figured which may be the tergum of the first genuine somite. Its size and lateral attenuation certainly suggest the first tergite of *Anthracomartus palatinus*; and it further resembles the first plate in *Eophrynus prestvicii* in being embraced at the sides by the lateral laminæ of the second, which are directed obliquely forwards and outwards. If this theory be adopted the differences between the first and second terga in *Kreischeria* and *Eophrynus prestvicii* are very considerable, for in the latter it is the second that is in process of obliteration and has become modified by the suppression of its tubercles, the first remaining normal in these particulars, while in *Kreischeria* the converse holds.

Another view of *Kreischeria*, however, may be entertained. The tergum that Haase regards as the second is much larger than those which he counted as the first and third, and it is possible that it represents two terga, namely, the second and third entirely fused, the process of fusion that is indicated in *E. prestvicii* having been carried to its completion in *Kreischeria*. This supposition gains some support from what is presented in the allied Arachnid *Brachypyge carbonis*, where the second tergal plate is also of large size and may represent the dorsal elements of the second and third, there being only eight terga traceable on the upper side of the fossil. There are reasons, too, for thinking that the first tergite also, although clearly enough defined, is fused to the second large plate in the form just mentioned.

These doubtful points will no doubt be settled by a re-examination of the fossils in question. In any case there appears to me to be no escape from the conclusion that nine tergal plates are visible on the upper side of the opisthosoma in *Eophrynus prestvicii*. As is explained below, the first of these has apparently no sternal

[1] Zeitschr. deutsch. geol. Ges., vol. xlii (1890).

equivalent on the ventral side. It probably therefore represents the tergum of the pregenital somite, and is thus comparable to the first tergite of the opisthosoma in the Pseudoscorpiones and Pedipalpi. The second then will be the tergal plate of the genital somite, like that of the two orders just named.

The smaller size of these two terga as compared with the third, both in *Eophrynus prestvicii* and *Anthracomartus völkelianus* and *palatinus*, recalls what is met with in the Pedipalpi, where also the anterior border of the second is emarginate for the reception of the first.[1]

The third, fourth, fifth, sixth, and seventh terga are, apart from their increasing recurvature, similar in form and structure, except that the median tubercles of the third are more coalesced and form a slightly larger and higher cluster. The eighth also is like those that precede it, except that the posterior lateral angle is produced into a spiniform process. A similar process is present upon the marginal lamina of the ninth. The central area of this plate, however, which is relatively narrow and compressed, is furnished with only two tubercles, representing the lateral pair of the four observable upon the preceding terga. Moreover, the tergum of the ninth somite is continuous posteriorly with a quadrate plate occupying the interspace between the marginal plates of the somite. Since there is no segmental line between this plate and the tergum, the former may be regarded as an expansion of the latter. In this case the ninth somite differs from the rest in being furnished with a median as well as two lateral expansions. This was the view adopted by Haase with regard to *Kreischeria wiedei* and *Anthracomartus völkelianus*, and by Ammon in connection with *Anthracomartus palatinus*. Both these authors, however, were in error, in my opinion, in looking upon the somite in question as the last abdominal somite. For in the figures they have published of *A. völkelianus* and *A. palatinus* the lateral expansions arising from the penultimate, their eighth, tergum are shown to be continuous on the ventral side, with a sternal area behind which at least one complete somite is represented. The same feature is exhibited in the figure of the ventral side of the abdomen of an Arachnid referred by Howard & Thomas to *Brachypyge carbonis*. It is also very manifest in the cast of *Eophrynus prestvicii* now under discussion. Moreover, it appears to me to be an open question whether the terminal median lamina that intervenes between the lateral laminæ of the ninth is an expansion of the tergum of that somite or of the tenth (the preanal) somite. When the opisthosoma of *Eophrynus* is viewed from the underside, the posterior median

[1] Since the pregenital somite is of inconstant occurrence within the class Arachnida, persisting in some orders (e.g., the Pedipalpi, Palpigradi, and Pseudoscorpiones) and obliterated in others (e.g., the Scorpiones, Xiphosuræ, and Solifugæ), I adopt the suggestion of Ray Lankester ("Arachnida" in Encycl. Brit., Suppl., 1902, p. 524) and regard it as a supernumerary somite, counting the genital somite as the first somite of the opisthosoma. The annexed figures [see pt. II] are numbered in accordance with this view of the matter. This fact must be borne in mind in comparing the figures and description.

lamina is seen to extend downwards and forwards to the anal plate and to be continuous on each side with the crescentic sternal sclerite of the tenth somite, which encircles the anal plate and is merely separated from the posterior lamina by a shallow groove on each side.

Here, then, three questions offer themselves for decision :—Does the crescentic sternal plate of the tenth somite belong to the somite of which the anal plate is the tergal representative? Or is the tergal region of the tenth to be found in a part or the whole of the area that lies behind (morphologically above) the anal plate? And is the posterior median lamina an extension of the tergal region of the tenth or of the ninth somite? If an affirmative answer be given to the first question, the number of somites of the opisthosoma will be fixed at ten. If the second question be answered in the affirmative, the number in question will be eleven, the anal plate representing the dorsal sclerite of a somite without sternal element. With regard to the third question, the absence of all divisional line on the dorsal side between the tergum of the eighth somite and the posterior median lamina in *Eophrynus prestvicii*, *Kreischeria wiedei*, and *Anthracomartus völkelianus* points to the correctness of Haase's view that the lamina belongs to the last somite visible on the dorsal side. Again, with regard to the second question, Haase's figure of the ventral surface of the posterior end of the opisthosoma of *A. völkelianus*, and that of the same region in *Eophrynus* (*Brachypyge*) *carbonis* of Howard & Thomas, attest the presence of a distinct annular somite, with sternal, tergal, and lateral regions in front of the anal plate. In *Eophrynus prestvicii* this same somite is recognizable, although its tergal area, lying behind (morphologically above) the anal plate, is very narrow, much narrower indeed than the corresponding area as represented in *Anthracomartus völkelianus.* This somite in *Eophrynus* I count as the tenth. The anal plate then represents the eleventh. This plate has the form of a transversely oval tubercle, and in one of the casts is marked by an incomplete transverse groove which suggests the possibility of its consisting of distinct sternal and tergal elements. If this be the case, the anal somite will resemble that of the Amblypygous Pedipalpi, rather than that of the Cyphophthalmous Opiliones. In other respects the segmentation of the posterior end of the opisthosoma closely resembles that of the last-mentioned group (e.g. of *Stylocellus*), where the last tergal plate, the eighth, visible on the dorsal side, overlaps the ninth; the latter forms a narrow ring round the tenth, of which the tergal element alone persists as the anal plate or valve, its sternal equivalent having apparently disappeared.

I can find only nine sternal plates as compared with the eleven tergal plates. The discrepancy may be accounted for by the disappearance of the sterna of the eleventh or anal somite, and of the first, which has probably atrophied in connection with the enlargement and mesiad approximation of the coxæ of the last pair of appendages, and is no doubt represented by the narrow area between these segments. Hence the first free sternal plate corresponds to the second tergal. The sternal plates are practically smooth but for the presence of a pair of tubercles on each side of those lying between and including the fourth and eighth. The innermost of these tubercles on each sternite are widely separated from the middle line. Beyond the external tubercles on the fourth, fifth, and sixth sterna there is on each side a conspicuous upstanding ridge, representing perhaps the lateral margins of the plates. Beyond this crest the lateral area of the somite slopes upwards to the margin of the lateral tergal lamina. It is noticeable that the posterior border of the fourth, fifth, sixth, and seventh is elevated, as is the case with the sterna in many Opiliones.

The posterior border of the third sternum is sharply defined, forming a pair of slightly arcuate crests stretching each from near the middle line to the lateral border. The median portion of this plate also presents a distinct and wide pit-like depression which evidently underlies and apparently has a direct connection, possibly in the way of muscular attachments, with the tubercular elevation on the third tergal plate. Since the lateral portions of the posterior border of the third sternum are more decidedly elevated and arcuate than those of the preceding or succeeding sterna, it is possible that the slit on each side they overlie represents the stigma of a respiratory organ. I can find no other structure on the sternal surface of any of the somites that suggests the stigma either of a tracheal tube or a pulmonary sac.

In front of the sternum of the third somite two sterna are, I think, traceable. The anterior of these, which probably belongs to the genital somite, is triangular in form, and projects forwards between the coxæ of the appendages of the last pair. Its posterior border is somewhat irregular, but shows a distinct though small median emargination. The second sternum is narrow. Its posterior border is sharply defined in the middle line, and exhibits a pair of lobate sclerites exactly similar in size and position to those on the second sternal plate of some of the Amblypygous Pedipalpi. There seem to be no reasons for thinking that the genital orifice was situated in front of the first sternal plate as it is in the Opiliones. Presumably it opened behind it as in the Pseudoscorpiones, Pedipalpi, etc.

The type of *Eophrynus prestvicii* gives the following measurements in millimetres:—Total length, 27; length of carapace, 8; its posterior width, 9; length of its median elevated area, 7; posterior width of latter, 4·5; length of opisthosoma, 19; its greatest width (approx.), 17; length of its sternal area from anterior end of first sternite to posterior end of anal tubercle, 16; length of coxa of fourth leg 5·5, trochanter 4, femur 9·5, patella 5; of same segments of third leg, 4·5, 3, 6, 3.

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

III.—The occurrence of *Marsupites* in Flints on the Haldon Hills.

By A. J. Jukes-Browne, B.A., F.G.S.

WHILE examining recently a collection of specimens from the flint-gravel of the Haldon Hills in the Museum of the Torquay Natural History Society, I discovered among them four containing casts of plates of *Marsupites testudinarius.* Moreover, in reply to enquiries, Professor Clayden, of Exeter, informs me that the Albert Memorial Museum there possesses five such plates, and that one was found by Mr. F. J. Collins, of Exeter, about three years ago, so that the fossil appears to be not uncommon in the Haldon flints, and consequently it seems worth while putting the fact of its occurrence on record, with some of the inferences that may be drawn from it.

The casts are in pale grey flint, and it is somewhat remarkable that they show a strongly marked arrangement of ridges corresponding with those on the more ornate varieties of *M. testudinarius.* As the inner surface of all plates of *Marsupites* is smooth, I conclude that the plates embedded in flint were partially silicified, but even then it is not easy to understand the persistence of the ornament, unless this is structural and not merely an external ribbing.

The coarse gravel which caps the Haldon Hills is now believed to be of Eocene age, and Mr. C. Reid has shown that the travel of the stones composing these Bagshot gravels has been from west to east. The flints, therefore, may be accepted as having been derived from masses of Chalk, which then existed at a higher level than the plateau which now forms the summit of Great Haldon.

The existence of *Marsupites* in the Haldon flints is interesting, because it testifies to the former extension of that zone of the Chalk which alone yields this peculiar genus of Crinoidea. Dr. A. W. Rowe has shown that the zone of *Marsupites* in the South of England always consists of two bands or sub-zones, the lower characterized by *Uintacrinus* and the upper by *Marsupites*, and further, that plates of the latter genus very rarely occur in the lower band, being almost restricted to the upper band.

No Chalk now exists on Haldon, and the nearest outlier of Upper Chalk is at Beer Head, a distance of about 18 miles, while the nearest outcrop of the zone of *Marsupites* is a little west of Dorchester, about 48 miles from the Haldon Hills. The highest zone now remaining in Devonshire is that of *Micraster cortestudinarium* (near Beer), but the fossils found in the overlying flint-gravel testify to the former presence of the zone of *M. coranguinum*, and it has always been tacitly assumed that the higher zones of the Chalk were also formed over Devon and other western counties. We have now positive evidence of the western extension of the zone of *Marsupites*, but at present there is no actual evidence of still higher zones.

So far as I can ascertain, no remains of Belemnites have been found in the Haldon flints. Professor Clayden has kindly made enquiries for me at Exeter, and has searched through the collection in the Albert Museum, but has not found any trace of Belemnites or of fossils characteristic of the zones of *Actinocamax quadratus* or *Belemnitella mucronata.* Of course this is negative evidence, but where *Belemnitella* is common in Chalk, as near Norwich, casts of its alveolar cavity are common in the flint-gravels, and one would expect the remains of this fossil to occur in the Haldon gravel if the zone of *Bel. mucronata* had been under erosion in Devonshire during the time of the Bagshot Beds. It should, however, be remembered that even if no fossils belonging to higher zones than that of *Marsupites* should ever be found on Haldon, their absence will not mean more than the absence of such zones within the area at the time when the Bagshot Beds were formed. It will not prove that the higher zones never extended into Devonshire, but simply that they were destroyed during the upheaval of the Chalk and before the formation of the Bagshot Beds.

The occurrence of the plates of *Marsupites* does, however, enable us to form an estimate of the total thickness of Chalk which may have existed in the neighbourhood of what are now the Haldon Hills when the Bagshot gravels were being accumulated. The Lower Chalk would be represented by only a few feet of calcareous sandstone, as on the Devon coast, and may consequently be neglected; the Middle Chalk is about 100 feet thick at Beer, and the mean thickness of the zone of *Holaster planus* in Devon is about 40 feet. To get an estimate of the thickness of the zones of *Micraster cortestudinarium* and *M. coranguinum* we must go to Dorset, where the mean of several measurements gives 80 feet for the former and 200 feet for the latter.[1] Finally, the thickness of the zone of *Marsupites* was found to be 111 feet near White Nothe, and *Marsupites* are only found in the upper 30 feet; if this depth was maintained to the westward, the total thickness of Chalk under erosion in Devonshire would be as follows:—

	feet.
Zone of *Marsupites testudinarius*	111
,, *Micraster coranguinum*	200
,, *Micr. cortestudinarium*	80
,, *Holaster planus*	40
Middle Chalk	100

We may therefore safely assume that the Haldon gravels represent the riddlings of about 500 feet of Chalk.

IV.—On a Cause of River Curves.

By C. Callaway, D.Sc., F.G.S.

In recent work on the laws of river-dynamics an important part has been taken by members of the Cotteswold Naturalists' Field Club. Dr. T. S. Ellis,[2] in 1882, announced the suggestive fact that the course of all the eastern tributaries of the Severn between

[1] See Dr. A. W. Rowe on "The Zones of the White Chalk of Dorset," in Proc. Geol. Assoc., 1901, vol. xvii, p. 11.

[2] "On some Features in the Formation of the Severn Valley." Read before the School of Science Philosophical Society, Gloucester. The geological world may perhaps be excused for overlooking the publications of this Society.

Berkeley and Tewkesbury was directed obliquely *up* the valley, a discovery which furnished the key to the relative ages of the Severn and the Thames.

Mr. S. S. Buckman also has worked with success in the same field, his ingenious paper in the GEOLOGICAL MAGAZINE[1] for August being only one of several contributions on river development. Some important observations on the curves of rivers have also been made by Dr. Ellis.[2] He remarks that all the affluents on both sides of the Severn in the Gloucester area come in on the *convex side* of the curves, and he notices that in all the windings of the Wye known to him, "where the river describes a great curve round a plain, one or more tributaries flow in at the convexity." Dr. Ellis considers that this effect is due to the tendency of the tributaries "to break away their banks on the lower side, at their confluence with the main stream, and to join together." This explanation I am unable to accept; but Dr. Ellis has hit upon a truth, and it has suggested to me the investigation of an interesting problem.

I have examined large numbers of Ordnance maps on the one-inch scale. They are from Western England, North, South, and Central Wales, the Lake District, the Highlands of Scotland, and many parts of Ireland. The result of this inquiry was the induction that in the vast majority of cases, probably nine out of ten, the affluents of the rivers enter on the convex side of the curves. This was true, not only of the main streams, but of the tributaries of the tributaries. I will give a few examples. The Severn between Shrewsbury and its junction with the Fyrnwy is about twelve miles in length as the crow flies, but probably nearly thirty miles in its actual course. Nineteen affluents are indicated on the one-inch map. Of these fifteen come in on the convex, two just above the convex, and two on the straight, but these are just opposite each other. Shrewsbury and Ironbridge are about thirteen miles from each other. The river makes numerous bends, generally in alluvium. Ten tributaries enter on the convex, two just above the convex, three on the concave, and two opposite each other, one on the convex, the other on the concave. Take the river Lug for a dozen miles below Leominster. About eight affluents enter on the convex, one comes in on the concave, and two enter opposite to each other, the *larger* stream on the convex side. Between Monmouth and Ross, a distance of nine miles as the crow flies, there are about a dozen flexures, with ten tributaries entering on the convex or just above it, and two on the concave, the concavities in the last two cases being subordinate to large convexities. The number of curves between Ross and Hereford (11 miles) is also very numerous, and *all* the fifteen affluents come in on the convex, or a little above it.

Turning to foreign countries, we discover the operation of the same law. For example, most of the tributaries of the Missouri enter on the convex side of the curves. Taking them from north to south, we notice that the rule is followed by the Big Sioux, the Kansas, the Mississippi, the Ohio, and many others, while I can find

[1] p. 366. [2] Loc. cit.

very few which come in on the concave. The same principle is seen to obtain in the Ganges, the Indus, the Po, the Danube, and every other great river system which I have examined. It is needless for me to multiply examples, as my statements can be easily tested by the inspection of reliable maps.

The coincidences I have pointed out cannot be accidental. They clearly indicate the operation of some law. They strongly suggest that the divergence of rivers in the direction of their affluents is due to the affluents themselves. How the divergence is produced I will now attempt to explain.

Let us suppose that a river is running straight forward, and a tributary comes in on one side at right angles. After heavy rains the affluent will bring down sediment, and will discharge it, or a part of it, into the main stream. Under ordinary conditions, a large proportion of this sediment will be carried obliquely down the river, and deposited on the opposite side, according to the law of the parallelogram of forces. Let AB (Fig. 1) be the river, and CD its affluent. Then let the line *ab* represent the force of the river in magnitude and direction, and *cd* the force of the affluent. Then a large part of the sediment brought in by CD will be carried along the line *cb*, and deposited at *b*. Some of the detritus may sink to the bottom before *b* is reached, and some of it will probably be carried down below *b*; but there must be considerable deposit at *b*, for at that point the lateral force *cd* will be balanced by the reaction of the bank, and the carrying power of the current will be reduced. Of course, the finer sediment will be transported further than the coarser particles, and *b* will be a short line rather than a point. The growth of this new land at *b* will cause a deflection of the current, which will impinge upon the opposite bank lower down, and will begin to excavate. A series of curves will thus be initiated according to principles which need no explanation in these pages.

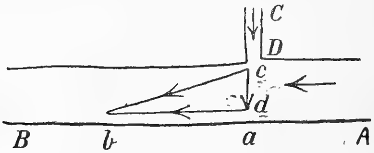

Fig. 1.—Affluent (C D) entering river (A B), and depositing sediment at *b*.

Not only will the deposit at *b* grow by additions from the affluent CD; it will form a barrier projecting into the stream, and in the slack water above it sediment from the main river will be thrown down.

According to the explanation I have just given, the normal position of the affluent should be a little *above* the convex curve, and this is very frequently found to be the case. But the new sediment thrown down above the projection formed at *b* will cause the projection to grow up-stream, so that in time it will reach as high as the tributary, or even higher; and the latter will enter, not above the convexity, but in some part of it. Fig. 2 will illustrate this point. The affluent CD enters the river AB above the convexity. But the delta-like mass of land E has grown up-stream, and the broken lines represent the new course of the river, with the affluent entering it at D′.

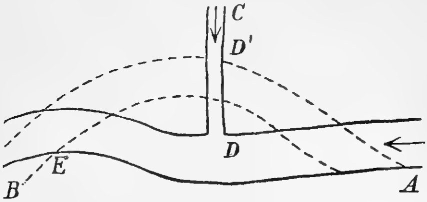

Fig. 2.—Growth up-stream of delta (E) formed by affluent C D, subsequently C D′.

The principles I have expounded are quite consistent with the occasional entrance of a tributary on the concavity of a curve. This may occur in several ways.

1. An affluent may originally have entered the river on the convex. Then a change may take place in the main stream by increase or decrease of slope or volume, so that a new set of curvatures may be produced, the causes in operation being powerful enough to overpower the effect of the affluent. Thus a concavity may take the place of a convexity.

2. An affluent may enter on the concave owing to its excessively swift motion. This appears to be the case in the valley of the Rhone near Sion. According to Lord Avebury,[1] the Borgne falls into the Rhone at this place with such velocity as to drive it to the opposite side of the valley, the affluent entering the Rhone on the concave across an alluvial flat. It would seem that the entry of the tributary was originally so swift that it struck the further bank and rebounded, so as to deposit its sediment *on its own side.* The growth of this delta would gradually force the Rhone to the opposite side of the valley.

3. Two affluents may enter a river opposite to each other. The one that entered with the greater velocity (up to a certain point) would be likely to come in on the convex, for it would have greater power to convey its sediment to the opposite bank, and thus to draw the river to its own side. The smaller tributary would of course come in on the concavity.

4. The entry of an affluent on the concave may be due to the deposit of sediment at the junction of the two streams. An interesting example of this occurs on the Severn, about 6 miles south-east of Shrewsbury. It is shown in Fig. 3. Cound Brook enters on the concave at A. The last mile of the course of the brook is through an alluvial flat. Now it appears highly probable that at one time the river curved round into this bay, as suggested by the broken lines; otherwise its excavation is not

[1] "Scenery of England," p. 319, fig. 133.

easily explained, since the affluent would not degrade, but deposit. If this supposition is correct, the brook must then have entered on the convex at B. Its current would thus meet the current of the river almost directly, the two opposing forces would cause partial equilibrium, and detritus would be thrown down. As this new land grew, it would push the Severn further and further towards its present position. At a late stage of the process, it would seem as if the opposing currents created the tongue of land CA, so that the brook is forced to fall into the river on the concave at A.

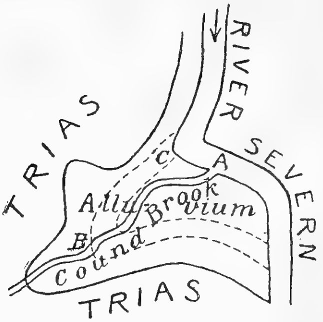

Fig. 3.—Junction of Cound Brook with River Severn, showing change of infall on the convex to infall on the concave.

It is evident that the effects produced at the confluence of a river and its tributary depend on very varied conditions. The most important of these are the angle between them, and their relative magnitude and velocity. It is conceivable, for example, that an affluent, even one of relatively large size, may fall into a river without giving rise to marked curvature. If the main river is flowing swiftly, and the affluent is sluggish, the latter will have too little momentum to materially disturb the momentum of the former. Part of the sediment carried by the tributary would be thrown down at its junction with the river, and the portion which entered the latter would be swept down for a considerable distance.

On the other hand, if the conditions are favourable to deposit on the opposite bank, an affluent will cause marked divergence of the main stream. This is well seen at the confluence of the Severn with the Tern, of the Wye with the Lug, of the Avon with the Arrow below Stratford, and of the Trent with the Tame. Besides the new deposits on the opposite bank, affluents may also create islands in the main river, as in the Severn at its junction with the Tern, and in the Teme at the infall of the Laughern Brook. Alney Island, at Gloucester, probably originated in this way. It is about two miles in length, with an arm of the Severn running down each side of it. The western arm receives the river Leadon and a smaller stream, while the Hatherly Brook and another affluent enter the eastern branch. The currents of these tributaries coming in on opposites may well have caused a certain amount of dead water, and consequent deposit of sediment. A small island formed in this way would grow by arresting the current of the Severn, whether the tide were descending or ascending.

I need hardly point out that my theory does not require an affluent at every convex curve. If the current of a river is once deflected, flexures may be produced indefinitely, in the manner described in textbooks. Nor does my explanation apply to tidal sections of rivers, since the alternations of current motion would obviously produce effects differing widely from those I have described.

The textbooks tell us that a series of river curves may be initiated by an obstruction, such as a tree or a fall of rock, producing a deflection of the current to the opposite bank. Or the curves may be caused by differential resistance in the materials through which the river is flowing. I have no objection to these explanations. They probably apply in some cases, but I think they are much less important than the theory I have proposed. They have been imagined rather than proved.

How far the explanation I have offered will apply to rivers which are now running in solid rock is a question into which I do not here propose to enter.

V.—Some Remarks on the Atlantis Problem.

By R. F. Scharff, Ph.D., B.Sc., F.Z.S.[1]

SINCE the dawn of early history the question of the existence of a continent beyond the "pillars of Hercules" has occupied the mind of man. Our very earliest records of this mythical land were derived from a narrative which has been handed down to us by Plato. According to it, Solon is said to have visited Sais in Egypt, and there to have heard from priests of the ancient "Empire of Atlantis" and of its overthrow by a convulsion of Nature. This Atlantis was then spoken of as a vast land lying beyond what we now call the Straits of Gibraltar, and it is supposed to have been inhabited by a mighty race of people. Plato's story has called forth quite a flood of literature, not only in ancient times; even within the last score of years many pamphlets and books have been published dealing with this attractive problem. Some authors have sought to discredit the veracity of Plato's assertions, while several, and among them Humboldt and Sir Daniel Wilson, were of opinion that the tale rests on some historic basis. Others, again, have utilised the original story and connected it with their own ideas of a land-bridge stretching right across the Atlantic from Europe to America.

The Atlantis problem, however, was only raised to scientific importance when modern research revealed the fact that the living as well as the extinct flora and fauna of Europe have quite a number of types in common with North America. Unger was the first to put forward the view, from a purely scientific reasoning, that the Atlantic Islands, that is to say, the Azores, Madeira, and Canary Islands, formed part of a land-connection which stretched right

[1] A paper read before the British Association in Section D (Zoology), Belfast, 1902.

across the Atlantic and still preserved some of the plants which invaded our Continent from the New World. Heer hailed this hypothesis with delight, while Andrew Murray adopted it in a somewhat modified form. Edward Forbes also occupied his fertile mind with the problem, but could not convince himself that the vast land which had evidently occupied a portion of the Atlantic had any connection with America. Wollaston, too, who had a most intimate knowledge of the Atlantic Islands, strongly supported the view that their fauna reached them across dry land.

Imbued, however, with the idea of the permanence of the great ocean basins, Wallace vigorously attacked one and all of these theories, and contended that there was not only no connection between Europe and America across the Atlantic, but that the fauna of the Atlantic Islands was derived from the adjoining continents of Europe and Africa by winds and marine currents. The weight of the arguments brought forward by Wallace silenced all critics for a time, and the influence of his views is traceable in most of the more recent writings on the subject. But since some leading geologists have expressed themselves against the theory of the permanence of the great ocean basins, the older views of a possible land-connection between Europe and the Atlantic Islands, and also between Europe and America, are again discussed. I have therefore collected together a number of facts in the distribution of animals which had not hitherto been utilised, in order to make a renewed attempt from a zoological point of view to solve the Atlantis problem.

The results of my investigations tend to show that Madeira and the Azores are the remains of an ancient tertiary area of land which was joined to Europe, and that it probably became disconnected in Miocene times. Since then this land once more became united with our Continent, and may not have been finally severed until the Pleistocene period. As regards the question of a land-bridge across the Atlantic, many reasons can be given in favour of such a theory. It must, however, have occupied a position farther south than the land just alluded to. Uniting North Africa with Brazil and Guiana in early tertiary times, it probably subsided during the Miocene period, leaving only a few isolated peaks as islands in the midst of the vast ocean which has since replaced it.

VI.—On the Geological Structure of Ireland.

By Professor Grenville A. J. Cole, F.G.S.[1]

In this illustrated lecture, the more prominent phases of the geological history of Ireland were pointed out, mainly as an explanation of the existing scenic features of the country. Probably very little remains in Ireland of the old Huronian continent, unless portions of it have appeared again in the cores of Caledonian folds. The stratified, but metamorphosed, Dalradians of the west may be

[1] A paper read before the British Association, Belfast, Sept., 1902, in Section C (Geology).

Cambrian, or older; and gneiss is included in the granite of eastern Tyrone, the latter being probably of Caledonian age. The gneiss of the ancient moorland between Omagh and Cookstown is, moreover, very possibly pre-Cambrian. The Silurian sea must have covered all the Irish area; and the subsequent Caledonian folding, with its axes running north-east and south-west, marked out the first distinct lines of the existing country. The arches became filled with molten rock as they rose, and denudation has again and again exposed in them a core of granite. To this folding we owe the guiding lines of Donegal, Sligo, and Mayo; the axis of Newry, which reaches from the sea—and, indeed, from Scotland—down into the midland counties; and, above all, the long mass of the Leinster Chain, the most important feature of south-eastern Ireland. The granites weather into round-backed moorlands; the schistose foothills give rise to picturesque ridges and ravines upon their flanks. In the Dublin area, between the foothills and the sea, quartzites and slates, usually regarded as Cambrian, have added the prominent features of Howth, Bray Head, and the two Sugarloaves, to an already diversified landscape.

The Old Red Sandstone lakes spread across the hollows of the Caledonian continent, to be succeeded by the inflow of the Carboniferous sea. The Lower Carboniferous beach-deposits are now found on the summits of west Irish mountains, and very little of the country can have escaped submergence. The Hercynian folding produced the second series of structural lines, assisted by the varying resistance of the Old Red Sandstone and the Carboniferous Limestone to denudation. The east-and-west anticlinal ridges, from the Atlantic to the Irish Channel, with intervening valleys, where the limestone is protected in the synclinals, repeat on a bold scale the structure of South Wales and Belgium. The folds swung round in the neighbourhood of the pre-existing Leinster Chain; and the axis of the Kilkenny Coalfield, where the Coal-measures remain on a high synclinal, runs north-east and south-west, like its neighbour on the east. The great limestone plain itself is probably to be looked on as a vast shallow synclinal of the same epoch, into which, in later periods, the Caledonian and Hercynian ridges poured down their detritus.

Marine Permian beds occur near Stewartstown, south-west of Lough Neagh, and also in the north of County Down. The terrestrial conditions of the British Trias were continued into the Irish area, but the remaining beds of this period all lie north of Dublin, and mostly owe their preservation to the capping of Cainozoic basalt. The Rhætic sea penetrated as far west as the Caledonian hills of Londonderry, and marine conditions continued during early Liassic times. An uplift then probably occurred, and the sea did not return till the middle of the Cretaceous period. The 'White Limestone,' which forms so distinctive a feature of the Antrim coast, represents the English Chalk.

The great feature of the north is, however, due to volcanic eruptions of Eocene age. Owing to the immense outpouring of basalt across the uplifted Cretacous and earlier strata, the counties of Antrim and Londonderry include high igneous plateaux, cut by deep valleys in which the underlying rocks are seen. The landscapes close around Belfast reveal the structure of the country in perfection. In the west of Ireland, dykes of basalt, running characteristically north-west and south-east, are so frequent as to show that the plateaux once prevailed from Down to the Atlantic coast. Sporadic eruptions occurred even in the Galway area, and basalt fragments prevail on the sea-floor between Ireland and Rockall. The granite of the Mourne Mountains was intruded in the same period of unrest, and the pinnacles and rocky walls of the group are a sign of youth when compared with the older granite areas in Ireland.

The existing surface of northern Ireland was determined by the falling-in and dislocation of the volcanic country that once spread northward to the Faröe Isles. Lough Neagh thus lies in a shallow basin formed during this epoch of subsidence and decay. The long sea-inlets of the north and west, including Belfast Lough and the 'rias' and 'fjords' of Connemara and Kerry, originated about the same time; but Ireland, now cut off from the lost continent on the north-west, became joined on to the growing continent of Cainozoic Europe. The spread of ice in glacial times is marked by numerous hills of gravel and eskers, especially in the central plain, where they form green ridges rising from the bogland and the prairie. The oscillations of level between the glacial epoch and the present day finally left Ireland cut off from Scotland, Wales, and England, with which her fundamental geological structure so obviously connects her. It is interesting to note that the most prominent features of her landscapes at the present day depend on structures impressed upon the area far back in Palæozoic times.

NOTICES OF MEMOIRS, ETC.

I.—British Association for the Advancement of Science. Belfast, September 11th, 1902.

Address to the Geological Section, by Lieut.-General Chas. Alexander McMahon, F.R.S., F.G.S., President of the Section.

Rock Metamorphism.

AFTER some prefatory remarks, the President said a brief description of a granite in the Satlej Valley of the Himalayas will, I think, introduce us by a short cut to the question of "contact metamorphism," an important branch of the subject under consideration. The granite I allude to is an intruder in the normal gneissose-granite of the Himalayas, and cuts through it at right angles to its foliation. The intruder, which is some yards wide, did not rise through a simple crack or fissure, for its passage upwards was interrupted by a sheet of dark intrusive diorite, older than itself, which ran, roughly speaking, parallel to the foliation of the gneissose-granite. This sheet of diorite offered considerable resistance to the rising granite. The granite zigzagged backwards and forwards across the diorite and ran along its edges for fifty yards or more, converting it into a mica trap. It then tore itself away and continued its upward course. The granite I am describing was in a molten or fluid condition at the time of its eruption, as I hope to show in my subsequent remarks.

I may pause here, however, to consider in passing what was the probable temperature reached by a granite such as that above described. The question is one of very great difficulty, as we know so little about the plutonic conditions of igneous rocks, and can only arrive at an answer to our question by indirect evidence. The melting-point of quartz ranges from 1425° to 1450° C., but the fusion-point of granite need not necessarily be as high as this, inasmuch as the presence of water at high temperature materially lowers the melting or solution point. The fusion-point of the other constituents of granite may here be mentioned: that of orthoclase ranges from 1164° to 1168°; microcline, 1169°; albite, 1172°; augite and hornblende, 1188° to 1200°; apatite, 1221°. Zircon, which is commonly found in granites, and is one of the first minerals to separate out of the magma, is shown by Ralph Cusack to have probably a melting-point of 1760°; whilst topaz, a not uncommon mineral in granite, is infusible up to the melting-point of platinum, namely, 1770° C.

If we consider, therefore, the melting-points of the mineral constituents of granite, we can hardly avoid the conclusion that for the magma to have attained perfect fluidity it must have reached a temperature of at least 1200° C. Vernadsky has shown that kyanite is transformed into sillimanite, a well-known product of contact-metamorphism, at a temperature of 1320° to 1380°. If rocks in contact with granitic masses have been raised to this temperature, it follows that the granite itself must have been still more heated. Vernadsky's observations have been relied on by Mr. George Barrow in his well-known paper "On an Intrusion of Muscovite-biotite Gneiss" in the S.E. Highlands of Scotland to account for the presence of sillimanite in the inner zone of metamorphism between the kyanite schists and the granite, and he considered that the temperature attained by the "central masses of the Highland rocks" was probably higher than the figures indicated by Vernadsky.

Bearing all these considerations in mind, including the influence of water and alkali in reducing, and of pressure in raising, the melting-point, I think we may safely infer that granites, such as the Himalayan granite alluded to above, must have been raised at plutonic depth to a temperature midway between red and white heat, that is to say, to at least 1200° C.

To return to the granite of the Satlej Valley under consideration, I wish to draw attention to its condition just before crystallisation commenced. A study of the mineral beryl will, it seems to me, throw light on this point. Beryl is an important accessory mineral of the granite under description. It is clearly an original mineral, and it is material to note that it was the first mineral to crystallise out of the magma of the Satlej granite. This is shown by several circumstances.

In the first place, the beryl preserved its perfect crystallographic shape, showing that its molecules during the entire period of crystallisation possessed comparative freedom of motion, and were not interfered with or molested by other solid minerals. In the second place, all the essential minerals of the granite when they subsequently crystallised out of the magma were deposited on the crystals of beryl. I have specimens of the granite showing crystals of beryl enclosed in felspar, in muscovite, and in quartz.

The beryl, therefore, having been the first mineral to crystallise, the examination of thin slices of it under the microscope ought to give us a clue to the condition of the magma at the time the beryl was formed. I have made such an examination, and I find that the beryl is crowded with liquid and gas cavities, the former containing movable bubbles and deposited crystals as well as water. The bubbles are of substantial size relative to the area of the cavities, showing that the water suffered considerable contraction after it was sealed up in the beryl.

Scrope long ago suggested that the fluidity of lavas below the melting-point was due chiefly to the water they contained, and attributed the liquidity of granite to the same cause. Scrope, however, in ascribing the mobility of an igneous rock to the presence of water, seems to have had regard principally or wholly to its mechanical action in furnishing an elastic medium in the interstices between the crystals or grains of the rock. He observes that a lava consists "of more or less granular or crystalline matter, containing minute quantities of either red-hot water, or steam in a state of extreme condensation, and consequent tension, disseminated interstitially among the crystals or granules, so as to communicate a certain mobility to them, and an imperfect liquidity to the compound itself," and he quotes Scheerer and Delesse, both of whom assert that water exists in mechanical combination with all crystalline rocks, "its minute molecules being intercalated between the crystals."

Nowadays one would attribute the liquidity of an igneous rock not so much to the mechanical action of the water present in it as to the combination of the water with the mineral contents of the lava, producing a state of solution. Sorby's investigations supported Scrope's observations, for he proved that the liquid contained in the inclusions in granite is water, and showed that it was caught up during the formation of the crystals, "and was not introduced subsequent to the consolidation of the rock." The water now contained in cavities in the beryl was probably held in solution by the constituents of that mineral at the time of its formation, and as it cooled down the water separated from the substance of the beryl and formed the cavities in which we now find it imprisoned. If this be so, it follows that when the beryl crystallised out of the magma, the latter was in a fluid condition, and held a considerable amount of heated water in solution. The temperature of the magma must have been above that of red heat, and the potential energy of the water held in a fluid state by pressure must have been great. When, therefore, in the course of the earth movements which accompany or in some cases are caused by the intrusion of eruptive igneous masses, pressure was temporarily relieved by the rupture and faulting of rocks, the superheated water contained in the magma would be ready to flash into steam with almost explosive violence. It must also be borne in mind that water under great pressure, at or above a red heat, has a powerfully solvent action on most minerals, even on so refractory a mineral as quartz. When, therefore, granite in the molten and fluid condition of the Satlej granite was erupted along a line of faulting, fissure, or weakness, the superheated water or steam, bearing with it much mineral matter in solution, must have acted with great chemical energy on the rocks into which it was intruded.

I have spoken of water carrying mineral matter in solution, and of a magma carrying water in solution. These two conditions may rapidly succeed each other under varying conditions of temperature and pressure. To use the words of Van Hise, "under sufficient pressure and at a high temperature there are all gradations between heated waters containing mineral material in solution and a magma containing water in solution." The condition of the beryl crystals, crowded as they are with liquid cavities, shows how high a proportion of superheated water was contained in the fluid granite magma at the time of their formation.

Sorby estimated that the fluid cavities in the quartz of granites sometimes amount to more than ten thousand millions to the cubic inch. As quartz, however, is usually the last mineral of a granite to consolidate, it may be thought that the water contained in it is a residuum left by the felspar and muscovite on their separation from the magma; but the case of the beryl above quoted shows clearly that the amount of water diffused through the magma before the mica, felspar, and quartz began to consolidate must have been very considerable. The amount of water held in solution by a granite, during the time of its aqueo-igneous fusion, cannot be estimated by the amount of water given in the analysis of consolidated and dried hand-specimens of that rock. A considerable proportion of this liquid must necessarily have been lost during the gradual cooling of the rock, and in the course of its intrusion into neighbouring sedimentary strata as sheets, dykes, and veins. Sorby, as the result of other lines of investigation, came to the conclusion that the amount of water present in granite, though limited, is considerable.

We must now turn for a few minutes to consider the important question of the porosity of minerals, and their permeability by heated water and gas at high pressure. The fact that solid substances are built up of molecules having interstitial spaces between them hardly needs demonstration nowadays. But have we all quite realised that the molecules of rock-forming minerals and crystals are not inert particles of matter, but that they vibrate or revolve or are endowed with other orderly movement that may be likened to the motion of the planets round the sun? Far, far away in space the solar system would, to an eye formed like our own, in all probability present a nebulous appearance, because the eye would not be able to see the individual members of our system. So, too, the molecules of which crystals are built up may have their appropriate motions, but we cannot see them with the eyes of sense because the molecules are beyond the highest powers of the microscope. We can, however, I think, perceive them with the eye of the scientific imagination; and the hypothesis that the molecules of minerals are separated from each other by intermolecular spaces, and have their modes of motion, seems essential to the comprehension of rock metamorphism.

The important experiments of Sir W. Roberts-Austen on the diffusion of gold in pure lead throw considerable light on this subject. Disks of solid gold were held against the bases of cylinders of lead by clamps, and were kept in an upright position at the ordinary temperature for four years. At the end of this time it was found that the gold had diffused upwards in the solid lead, for a distance of 7·65 mm., in sufficient quantity to be detected by the ordinary methods adopted by assayers. Traces of gold were found still higher. When a column of molten lead, 16 cm. high, was placed above solid gold and kept at a mean temperature of 492° C., that is to say, at 166° above the melting-point of lead, but 569·7° below that of gold, the gold diffused in considerable amount, to the top of the lead column, in a single day.

Sir W. Roberts-Austen's experiments, above alluded to, demonstrate that even such metals as gold, whose melting-point is as high as 1061·7° C., exhibit a measurable amount of kinetic energy at the ordinary temperature and pressure. Great results may no doubt be brought about at ordinary temperatures and pressures, when time, as in the laboratory of nature, is practically unlimited; nevertheless, the importance of high temperature and high pressure, in operations connected with metamorphism, can hardly be overrated. Not only does a rise in temperature increase the energy of the chemical actions and reactions which produce the mineralogical changes embraced by the term metamorphism, but it increases the porosity of minerals and facilitates the passage of liquids and gases through their pores. The cohesion of molecules is lessened, the amplitudes of their vibrations, rotatory or other movements, are increased, and a passage is opened for the advance of chemical materials into the heart of the crystal.

Increase of temperature thus not only throws open the doors of the mineral fortress attacked, but gives enhanced energy to the invaders. The fact that the mineral components of a rock are, under conditions of heat and pressure practically porous to heated water, laden with chemical reagents in solution, is frequently brought home to the mind of the petrologist in a very tangible way. We sometimes observe, for instance, that metamorphic changes begin at the heart of a crystal, and leave the peripheral portions of it fresh and unaltered. In such cases the chemical agents of change have evidently passed freely through the outer parts of the crystal, and have by preference selected its internal parts for attack.

In order to explain clearly how this remarkable result takes place, in the cases referred to, it will be necessary to diverge for a few minutes to consider another branch of our subject. It is difficult, if not impossible, to lay down any hard-and-fast rule of universal application, because the conditions under which igneous rocks crystallise vary with temperature, pressure, the relative proportion of constituents, and other local causes, and these variations in the conditions may materially affect the results; but I think the rule that minerals crystallise out of a molten magma in the order of their basicity is of very frequent if not of absolutely general application. This rule also governs the growth of individual crystals, especially those that exhibit what is known as zonal structure. Take, for instance, the felspars of an igneous rock. A gradual passage may frequently be traced by the petrologist from one species of felspar at the heart of a crystal to another distinct species at its periphery. Sometimes a crystal is made up of more than two species, which shade more or less gradually into each other. In accordance with the rule laid down above, the more basic species formed first; then, as the percentage of the bases left in the magma gradually decreased, owing to the first formed crystals having taken a lion's share of the available bases, the felspars that formed later became gradually more and more acid in composition. Thus a large felspar of slow and gradual growth may be composed of several zones, each zone being successively less basic and more acid than that upon which it crystallised, each successive zone thus possessing slightly different physical properties from the one that formed before it. These statements are capable of proof. When sections of felspars, such as occur in thin slices of igneous rock, are examined under the microscope in polarised light, petrologists can distinguish one species from the other—when the direction in which the sections were cut is approximately known—by measuring the angles at which they extinguish from the twinning or the pinacoidal plane.

This is not mere theory. Each species of felspar has its own angle of extinction and its own index of refraction. The determination of these two factors enables a petrologist to prove optically the change in composition; or, in other words, the change in species which has taken place in the successive zones during the gradual growth of a large zonal felspar.

Another general rule must now be mentioned. I think it may safely be asserted as a broad rule, that the different species of felspars are attackable by the chemical reagents which make themselves felt in metamorphic action, in the order of their basicity; that is to say, the more basic felspars are more easily attacked than the acid ones. When we bear in mind the facts stated above, we shall, I think, be able to see clearly how it is that the peripheral portions of large felspars in igneous rocks sometimes escape alteration, whilst the cores of these crystals are converted into secondary minerals, such as chlorite, silvery mica, zoisite, epidote, kaolin, steatite, saussurite, calcite, and scapolite. The chemical reagents flowing in solution through the pores of the felspars, pass by the more acid and refractory species, and devote their energies to the more susceptible basic species entombed at the heart of the zonal crystals.

The point I wish to enforce most strongly is that the phenomenon above described, namely, the formation of secondary metamorphic minerals in the interior of a crystal, combined with the comparative immunity to change of the external portions, shows that the agents which brought about chemical changes at the core of the crystal flowed freely through its unaltered peripheral portions.

But some may ask whether the chemical agents referred to may not have gained access to the heart of a crystal by a crack. I answer that a crack is a coarse and tangible object that looms large under the microscope. A crack in a mineral liable to metamorphic action, through which chemical reagents have flowed, could not escape detection. The finest crack through a homogeneous mineral, such as, for instance, an olivine, can be readily seen, not only by the small canal worn by the corrosive action of the chemical agents that flowed through it, but by the alteration set up in the mineral along the whole course of the canal.

I have a thin slice from a beautifully fresh olivine contained in one of the lavas of Vesuvius collected by myself. A volcanic explosion or other cause, operating after the crystallisation of the olivine, produced a very fine crack in the mineral through which water, charged with chemical reagents, subsequently flowed. The crack, though of microscopic width, is filled with serpentine, and on both margins fibrous serpentine has been formed at the expense of the parent olivine, and constitutes a fibrous band on both sides of the crack throughout its entire length, the direction of the fibres being at right angles to the crack. The rest of the olivine is of virgin purity and polarises in the most brilliant colours, contrasting strongly with the serpentine.

In this case it is clear that the chemical reagents, though free to flow along the crack, had commenced to extend beyond its walls, encouraged thereto by the porosity of the olivine itself. But how different is this case from those in which the entrance of the chemical agents had not been facilitated by a crack. In the case above described, the chemical changes set up were limited to the borders of the crack, and even had they gradually extended in the course of time to the whole of the olivine, the original canal by which the chemical reagents had gained access to the crystal would have remained to tell its tale, and exhibit along its course the banks of iron oxide thrown up by the chemical navvies that had excavated it.

Cracks save time as roads and canals do, but they leave behind them evidence of their former existence. In order to understand fully how rocks and minerals are so completely open to the attacks of chemical reagents, which penetrate to and produce chemical and mineralogical changes at the very hearts of minerals, we must fully realise how completely porous rocks and minerals are to the heated liquids which carry these reagents with them in solution. Heat, as before stated, not only increases chemical energy, but destroys more or less completely the cohesion between molecules, and increases the amplitude of the vibrations, or other motions of the molecules, and consequently facilitates the entrance of liquids and gases into the pores of minerals, and their complete permeation by these powerful agents of change. Thus far we have been chiefly concerned with some of the principles underlying the branch of our subject embraced by the term contact-metamorphism, which implies operations conducted at considerable depths below the surface of the ground, under conditions of heat and pressure.

We must now consider very briefly changes produced at or near the surface by the agency of water, or, as Bischof in his well-known work termed it, metamorphism in the 'wet way.' No hard-and-fast line, however, can be drawn between the two classes of operations, as the one gradually shades by fine gradations into the other. At one end of the scale we have high pressure and high temperature, and a fluid igneous magma holding water in solution, above a red heat, and giving up heated water or vapour charged with salts to the rocks in contact with it. Passing to the other end of the scale through diminishing temperatures and pressures, we reach a condition in which the water circulating through the rocks at ordinary pressure and temperature is more abundant in amount, and holds acids and salts in solution, capable of setting up important chemical reactions in the rocks and minerals to which it gains access.

In the case of surface operations, moreover, the metamorphic agents—water, acids, salts—are being constantly renewed. Conditions differing as widely as the conditions at the extreme ends of our scale do not yield, however, precisely the same results. In both metamorphic change goes on with more or less briskness, but the products are different. Some minerals require great heat and great pressure for their production, and such minerals are never formed by any surface process of weathering. For instance, the temperature reached determines whether titanium dioxide crystallises as rutile, or in one of its other two forms, rutile requiring a temperature of over 1000° C., and being the only form of titanium dioxide 'stable at a high temperature.'

Temperature also seems to determine whether the silicate of alumina crystallises as andalusite, kyanite, or sillimanite, the two former being transformed into the latter, at a temperature of 1320° C. to 1380° C. On the other hand, some minerals require little heat for their formation, and are readily produced by metamorphic changes in the 'wet way.'

There seems to be some correspondence between the melting-point of minerals and their density; thus, in the case of eleven minerals produced by contact-metamorphism, whose average specific gravity ranges from 3·06 to 4·03, I find that their melting-point ranges from 954° to above 1770° C., high temperature and high pressure (a concomitant of plutonic conditions) appearing to be factors in the production of high specific gravity in minerals.

The genesis of individual species of minerals is a fascinating study, but the subject is too large to enter upon here.

Water gains access to rocks in several ways. It falls as rain; it rises from hidden depths; it leaks from the sea into horizontal beds or into strata dipping away from it; and it penetrates through faults and fissures. Rain in its descent takes up from the air oxygen, nitrogen, carbonic acid, and in some cases small amounts of nitric acid. It is thus in itself a powerful solvent and potent agent in producing chemical change. In its passage through the surface soil it dissolves humic and other organic acids, the products of vegetable decay, which add greatly to its solvent power and enable it to break up many silicates and to dissolve even silica. By the time the rain-water reaches the solid rocks below the surface soil, it has become a very active agent in producing chemical change in them. It is by such agents, persistently applied during long periods of time, that large areas of ultra-basic igneous rocks have been altered into serpentine.

Hot springs are a well-known instance of water rising in considerable quantity from plutonic depths. They are known to occur in the plains of India, and are especially abundant in the Himalayas. I visited two very interesting ones at Suni, in the bed of the Satlej River, west of Simla. The springs rise apparently under the very bed of the river, and come to the surface on both banks within a yard or two of the rushing water of the Satlej. When I visited the springs they had a temperature of 130° F., and contrasted strongly with the cold water of the river flowing past them, which had descended from high Himalayan glaciers and had a temperature of 49° F.

The native inhabitants of neighbouring villages told me that the hot springs always appear at the very edge of the river, whatever may be the height of its waters during drought or flood. This statement is probably true, for I think the springs well up from below through the walls of a fault that traverses the bed of the Satlej at a high angle to its course, and the springs thus come to the surface on both its banks.

The metamorphic influence of these springs on the rocks in this locality has been very powerful. The ancient volcanic rocks there exposed have, for some distance up the river, been altered by aqueous agents almost out of recognition. The original structural characters of these lavas have been almost completely broken down, and an amorphous substance substituted for the crystals and minerals of which they were originally composed.

This result shows that the crystals and minerals of these old lavas must, for all practical purposes, have been completely porous to the aqueous agents brought to bear on them.

The general transmutation of one mineral into another by the action of heated water holding mineral agents in solution, aided by heat and pressure, may take place in a variety of ways. Some of these processes are simple, but others are highly complex. Many are the results of a single operation, others of a series of changes, some of which prepare the way for those that follow. In some cases the change may be brought about by the removal, in whole or in part, of one or more of the essential constituents of a mineral, whereby the relative proportions and mutual relations of those that remain are altered, as the following examples will show.

By loss of water limonite passes into hæmatite, and opal into crystalline quartz. Dyscrasite, by loss of antimony, passes into native silver, and pyroxene, by the removal of its lime and iron, is changed into talc. Simple oxidation or the absorption of oxygen by a mineral is responsible for another class of changes, as in the conversion of zinc blende into goslarite, and antimony into valentinite.

The loss of one or more of the ingredients, concurrently with the introduction of one or more new ones, causes many metamorphic changes, as in the conversion of marcasite into magnetite, of witherite into barite, and of azurite into malachite.

The well-known conversion of a peridotite into serpentine is a case in point. Here, part of the iron and magnesia is removed from the olivine, and water is introduced. A simple process like this, brought about by the percolation of surface waters through an igneous rock, is sufficient to transform considerable areas of rock masses into serpentine, as has been the case in parts of Cornwall.

Some metamorphic processes are more complex than those alluded to above, but Nature has unlimited time at her disposal, and is able to manufacture potent chemical reagents as her processes proceed. For instance, the sulphides of various metals of common occurrence in rocks, most of which, with the exception of those of the alkaline metals, are insoluble in water, by taking up oxygen pass into sulphates, most of which are soluble in that liquid at the ordinary temperature. These sulphates are readily carried away in solution, and become potent factors of change in rocks through which water charged with these salts flows. Again, carbon dioxide, so abundant in percolating water, decomposes minerals containing lime or alkali, and removes them as soluble carbonates to effect powerful chemical reactions elsewhere.

I must pass over the subjects of paramorphism and pseudomorphism, as the limited time at my disposal does not permit me to enter upon these subjects. In the above sketch I have entered upon a discussion of some of the leading principles that seem to me to underlie contact action and metamorphism in the wet way, because I venture to think that, if we really understand these two divisions of our inquiry, it will be unnecessary on the present occasion to enlarge on other branches of our subject.

Take, for instance, what is commonly called dynamic-metamorphism. The main factors in this kind of metamorphism are the folding, crumpling, crushing, and shearing of rocks by earth movements, especially during the upheaval of mountains. But these dynamic forces are potent factors in the development of heat. In the case, therefore, of dynamic-metamorphism, as in contact-metamorphism, pressure and heat are the main factors acting in conjunction with the water shut up in or circulating through a rock. If we understand how these factors operate and produce the results we see in cases of contact-metamorphism, we shall not fail to understand their action in a case of dynamic-metamorphism.

These observations also apply to regional metamorphism; that is to say, to metamorphism produced in rocks at great depth, by being brought within the influence of the interior heat of the earth. The action of heat in increasing molecular motion and kinetic energy is well understood nowadays, and so long as we get heat it seems to me immaterial how heat is generated in rocks subject to metamorphic action.

In the above sketch I have intentionally omitted to enter into the details of chemical action that has brought about individual cases of metamorphic change. Volumes would be required to do justice to so complex a subject, and the details would, in an opening address, be out of place.

In conclusion, I have, I trust, shown how important a part water plays as an agent of metamorphism, not only at and near the surface of the earth, but at plutonic depths. We have seen that the molten granite of the Satlej Valley, which was given as an illustration of a fluid igneous magma, contained a considerable proportion of water held in solution at considerably above red heat, and that the fluidity of the magma was due to its presence. We also saw that the great heat to which the magma was raised increased the potential energy of the contained water; a relief of pressure then opened the way for the intrusion of the molten magma into neighbouring rocks. We also saw that this water was rendered by heat a powerful solvent, and that it carried with it into the adjoining rocks the mineral matter of the granite in solution. We also saw that heat increased the porosity of minerals, facilitated the passage of liquids laden with mineral matter through their pores, and increased the potency of chemical action.

II.—List of Titles of Papers read before the British Association for the Advancement of Science, Belfast, Sept. 10–17, 1902, in the Geological and other Sections bearing upon Geology.

Section A (Mathematical and Physical Science).

Dr. Isaac Roberts, F.R.S.—Illustrations obtained by Photography of the Evolution of Stellar Systems.

Major S. G. Burrard, R.E.—On the Figure of the Earth.

J. Milne, F.R.S.—Observations on Earthquakes.

Report of the Seismological Committee.

Section B (Chemistry).

Dr. J. H. Gladstone.—On Fluorescent and Phosphorescent Diamonds.

Section C (Geology).

Lieut.-Gen. C. A. McMahon, F.R.S., F.G.S., President.—President's Address—Rock Metamorphism. (See p. 458.)

Professor Grenville A. J. Cole.—The Geology of the Country in the Neighbourhood of Belfast.

Joseph Wright.—On the Marine Fauna of the Boulder-Clay.

R. J. Ussher.—Report of the Committee to Explore Irish Caves.

Dr. Henry Woodward, F.R.S.—On the Middle Cambrian Trilobites, etc., of Mount Stephen, British Columbia.

H. J. Seymour.—List of Minerals known to occur in Ireland.

Dr. C. W. Andrews.—On the Tusks and Skull of *Tetrabelodon (Mastodon) angustidens.*

Dr. Henry Woodward, F.R.S.—Report of the Committee for the Registration of Type-Specimens of British Fossils.

R. Clark.—Notes on the Fossils of the Silurian Area of North-East Ireland.

H. B. Woodward, F.R.S.—Note on the Occurrence of Bagshot Beds at Combe Pyne, near Lyme Regis.

Professor J. Joly, F.R.S.—On the Viscous Fusion of Rock-forming Minerals. (See p. 475.)

J. J. H. Teall, F.R.S.—The Drift Map of the Dublin Area.

H. Kynaston.—Note on the Volcanic Rocks of Glencoe, and their Relation to the Granite of Ben Cruachan.

James Stirling.—Notes on the new Geological Map of Victoria.

Professor J. F. Blake.—On the Original Form of Sedimentary Deposits. (See p. 473.)

Professor H. G. Seeley, F.R.S.—On Cretaceous Fossils from the Salt Range of India. (See p. 471.)

Madame Christen.—Investigations into the Glacial Drifts of the North-East of Ireland, conducted by the Belfast Naturalists' Field Club.

P. F. Kendall.—On the Brockrams of the Vale of Eden, and the Evidence they afford of an inter-Permian Movement of the Pennine Faults.

——— Report of the Committee on Erratic Blocks.

William Mackie, M.D.—The Condition under which Manganese Dioxide has been precipitated in Sedimentary Rocks.

——— The so-called Fossil Water of the Sedimentary Strata and Sandstone of the Moray Firth.

Professor Grenville A. J. Cole.—On the Geological Structure of Ireland. (See p. 456.)

R. H. Traquair, M.D., F.R.S.—On the Fishes of the Lower Devonian Roofing Slate of Gemünden, Germany.

G. Barrow.—On the Prolongation of the Highland Border Rocks into County Tyrone.

E. A. Newell Arber.—The Fossil Flora of the Cumberland Coalfield.

R. Lloyd Praeger.—The Post-glacial Deposits of the Belfast District.

A. R. Dwerryhouse.—Report of the Committee on the Movements of Underground Waters of North-West Yorkshire.

A. Smith Woodward, LL.D., F.R.S.—On a Lower Carboniferous Fish-Fauna from Victoria, Australia. (See p. 471.)

Professor W. W. Watts.—Report of the Committee for the Collection and Preservation of Geological Photographs.

H. W. Monckton.—On the Valleys at the head of the Hardanger Fjord, Norway. (See p. 476.)

———— A Summary of the Principal Changes in South-East England during Pliocene and more recent times.

A. R. Hunt.—The evidence of the Hydrothermal Metamorphism of the Schists of South Devon. (See p. 474.)

W. G. Fearnsides.—Some new Faunas from Pen Morfa near Tremadoc, North Wales.

A. K. Coomáraswámy.—Note on the Scenery of Ceylon. (See p. 476.)

Dr. Wheelton Hind.—Report of the Committee for studying Life-zones in the British Carboniferous Rocks.

W. Barlow.—Report of the Committee on the Present State of our Knowledge of the Structure of Crystals.

SECTION D (ZOOLOGY).

Dr. R. F. Scharff.—Some Remarks on the Atlantis Problem. (See p. 455.)

Dr. Henry Woodward, F.R.S. (on behalf of *Dr. C. W. Andrews, B.A., F.G.S.*).—Note on the Skull of *Mastodon angustidens.*

C. Davies Sherborn.—Index Animalium.

J. Stanley Gardiner.—The Breaking-up of Coral Rock by Organisms in the Tropics.

SECTION E (GEOGRAPHY).

Dr. H. R. Mill.—Antarctic Expeditions.

W. S. Bruce.—The Scottish National Antarctic Expedition.

Sir Clements Markham.—Note on Captain Sverdrup's North Polar Expedition.

Rev. W. S. Green.—Rockall and Porcupine Bank.

Professor W. W. Watts.—Charnwood Forest, a buried Triassic Landscape.

J. Milne, F.R.S.—World-shaking Earthquakes, with Special Reference to the Recent Volcanic Eruptions in the West Indies.

Dr. Herbertson.—Preliminary Note on the Windings of Evenlode.

Mr. Porter.—Cork Valleys.

Professor Johnson.—Peat.

Dr. Johnston.—Survey of the Scottish Lakes.

Professor Libbey (of Princeton University, N.J., U.S.A.).—The Jordan Valley.

SECTION G (ENGINEERING).

R. G. Allanson-Winn.—Material bearing Ocean Currents.

SECTION H (ANTHROPOLOGY).

W. J. Knowles.—On Objects of the Plateau kind from the Interglacial Gravels of Ireland.

———— On Stone-Axe Manufactories in Ballymena, nr. Cushendall.

———— On the Manufacture of Stone Arrowheads and Spearheads.

Miss Nina F. Layard.—On a recent discovery of Palæolithic Deposits in Ipswich.

E. Cunnington.—Palæolithic Implements from Knowle, Wiltshire.

R. M. Young.—Notes on the Excavation of a Settlement of Irish Elk-hunters at Balloo Bay, Groomsport, County Down.

SECTION K (BOTANY).

A. C. Seward, F.R.S., and E. N. Arber.—Fossil Nipa Fruits from Belgium.

Miss Margaret Benson, D.Sc. — The Seed-like Fructification of *Miadesmia membranacea* (Bertrand), a Lycopodiaceous Plant from the Coal-measures.

——— A Possible *Calymmatotheca* type of Fructification showing Structure.

James Lomax.—On some New Features in Relation to *Lyginodendron Oldhamium.*

Dr. D. H. Scott, F.R.S.—Sporangiophores as a clue to Affinities among the Pteridophyta.

Miss Sibille O. Ford.—Notes on the Morphology and Past History of the Araucarieæ.

James Lomax.—On the Occurrence of the Nodular Concretions (Coal Balls) in the Lower Coal-measures.

Professor F. W. Oliver, D.Sc.—On Ancient and Modern Seeds.

III.—FOSSILS FROM CRETACEOUS STRATA IN THE SALT RANGE. By Professor H. G. SEELEY, F.R.S., V.P.G.S.[1]

HITHERTO there has been no evidence of Cretaceous strata in the Salt Range of the North of India. But Mr. Ernest G. Fraser, formerly of the Punjab Civil Service, has found many species of the type or age of the Upper Greensand. In 1893 he crossed the Salt Range and made a collection, placed in my hands, in which are the usual Primary, Secondary, and Tertiary types indicated by Mr. Wynne. But in addition are typical Cretaceous species in limestone. Among the more abundant are *Spondylus costulatus* (Stol), *Spondylus calcaratus* (Forbes), *Hinnites andoorensis,* and *Lucina arcotina.* The specimens are in good preservation, and weathered out from the rock. They are from the shoulder of Sekasar. Mr. Fraser did not draw a section; but the fossils which are deposited in the Royal Indian Engineering College show that the section must have been similar to those given by Mr. A. B. Wynne, except that Mr. Fraser had the good fortune to find Cretaceous fossils below the Tertiary strata. This northward extension of the fossils suggests that the Indian Cretaceous sea may possibly have been continuous with that of Central Asia, though the beds described by Dr. F. Schmidt in Siberia have fossils of a Gault type which has not yet been recognised in the Salt Range of India.

IV.—PRELIMINARY NOTE ON A CARBONIFEROUS FISH FAUNA FROM VICTORIA, AUSTRALIA. By A. SMITH WOODWARD, LL.D., F.R.S., of the British Museum.[2]

THE researches of Dr. Traquair have proved that in Britain there is a definite succession of Devonian and Carboniferous fish faunas. When sufficiently well-preserved fossils are available, these faunas can be readily distinguished and recognised, and they

[1] Abstract of a paper read before the British Association, Belfast, Sept., 1902, in Section C (Geology).

[2] Read before the British Association, Belfast, Sept., 1902, in Section C (Geology).

always occur in the same stratigraphical order. There is also considerable evidence of a similar succession on the continent of Europe, in Spitzbergen, and in North America.

Much interest was therefore aroused, twelve years ago, when the late Sir Frederick McCoy announced that a mixture of representatives of all these different faunas had been discovered in a bed of Palæozoic Red Sandstone in Australia.[1] These fossils were found at the supposed base of the Carboniferous system in the valley of the Broken River, near Mansfield, Victoria. The first fragments were discovered by Mr. Reginald Murray; a large series of remains was afterwards collected by the Rev. A. Cresswell for the Geological Survey of Victoria; and valuable additions were also made by Mr. George Sweet, F.G.S., of Melbourne. The complete collection was placed in the Melbourne Museum, and Sir Frederick McCoy's report was the result of his preliminary study of it.

Unfortunately, notwithstanding the interest of this important discovery, no definite information concerning it has hitherto been published. Before his death McCoy was only able to supervise the drawing of some plates to illustrate a memoir which he hoped to prepare. The specimens proved to be too fragmentary, and the materials for comparison in the Australian museums too inadequate for him to arrive at any satisfactory results. The whole collection has therefore been sent to me by Professors Baldwin Spencer and J. W. Gregory; and at present I have the honour of preparing the projected memoir for the Geological Survey of Victoria.

With ample facilities for the study of the collection, it now appears that McCoy's original report was based on a complete misinterpretation of many of the fragments. Far from displaying a "mixture of Lower Devonian, Upper Devonian, and types related to some of the Calciferous Sandstone series," as McCoy supposed, the Broken River collection is typically and essentially Carboniferous; and some of the specimens are of great interest, both from the ichthyologist's and from the geologist's point of view.

None of the specimens or drawings are labelled with the names proposed for them by McCoy, and none of his manuscript notes are forthcoming. I am thus unable to recognise all his identifications with certainty. Most of them, however, are distinguishable; and it is, in any case, sure that I have the whole of the material which was at his disposal.

The fossils regarded by McCoy as Lower Devonian in facies received the names of *Rytidaspis murrayi* and *Pteraspis* (?) *mansfieldensis*. The former was said to be of the same shape as *Cephalaspis*, the latter not more than generically distinct from *Pteraspis*. There are, however, in the collection no remains either of Cephalaspidians or Pteraspidians, or any types related to them. I do not know to which fossil the name *Rytidaspis* was applied, but it is evident that impressions of some gular plates of a large Rhizodont fish were mistaken for the supposed *Pteraspis*.

[1] F. McCoy, "Report on Palæontology for the year 1888": Ann. Rep. Sec. Mines, Victoria, 1889 (1890), pp. 23, 24.

The determination of the remains, claimed to be of a later Devonian type, is equally unsatisfactory. The only Acanthodian sufficiently well preserved for discussion is not specially related to the Devonian forms, but has the elongate shape characteristic of the genera of the Carboniferous and Permian periods. The Acanthodian fragment compared with the Devonian *Cheirolepis* (which is not an Acanthodian) is too imperfect for consideration. The so-called scales of the Devonian *Glyptolepis*, or an allied genus, evidently belong to the large Rhizodont already mentioned, and closely resemble the scales of the Lower Carboniferous *Rhizodus* itself. The Australian fish, however, does not belong to the latter genus, its teeth being round in transverse section.

The most interesting of all the genera represented in the collection is one rightly recognised by McCoy as an Elasmobranch allied to the Carboniferous *Gyracanthus*. It is named *Gyracanthides*, and is a round-bodied Acanthodian fish, apparently toothless, with the comparatively small and spinous pelvic fins advanced far forwards, as in *Acanthodes*. Its dorsal fins have not been observed, but its small anal fin is armed with a spine.

There is also evidence of a small Dipnoan fish with teeth and scales like those of the Carboniferous and Permian *Sagenodus*. The typically Carboniferous Palæoniscidæ in the collection are related to *Elonichthys*.

There is thus no abnormal mingling of genera in the Early Palæozoic fish fauna from the Broken River, Victoria. It is a typical Carboniferous assemblage without any extraneous elements.

V.—On the Original Form of Sedimentary Deposits. By Rev. Professor J. F. Blake, M.A., F.G.S.[1]

In determining the position and outline of ancient continents by observing the direction in which the sediment derived from them thickens or thins, and in interpreting the significance of the contours of the sea-bottom, it is necessary to consider what will be the actual shape as a whole of any sedimentary deposit of single origin in relation to the land whence it is derived.

It has been assumed by several authors, both of text-books and of special memoirs, that sedimentary deposits are thickest near their source of origin, and that limestones are deposited at great distances from the shore. The author gives reasons for taking a somewhat different view. The action of tides and currents is considered as a subsequent operation, the original form of the deposit is that which would result in a tideless sea, in the case of a river carrying detritus directly outwards. The coarse material, which is pushed along the bottom of a river, fills up the angle between the lowest level the river reaches and the constantly deepening bottom of the sea, and the deposit is consequently wedge-shape towards the land and sharply sloping seawards, like the tip of a railway embankment. The detritus which floats consists of all that has too low a power

[1] Abstract of a paper read before the British Association, Belfast, Sept., 1902, in Section C (Geology).

of sinking to overcome the velocity of the stream, and only begins to sink on the retardation of that velocity. The detritus with any particular rate of sinking will thus descend faster and also be crowded into a narrower area at a distance from the shore, and so form a thicker deposit there, where alone there is permanently room for it. This result will be modified by (1) the expansion laterally of the retarded stream, (2) the evaporation of the surface water, (3) the mixture with sea-water, (4) the superposition of various maxima at different distances from shore, (5) the redistribution by tides and currents.

During the continuance of constant physical conditions the seaward boundary of river-brought deposits will thus be a marked line—the 'mud-line' of Dr. Murray—at various depths, according to circumstances. At this line there is a rapid change of slope. This has been called an escarpment, and the edge of the continental plateau, but it is suggested that it is really the limit of terrigenous deposits in bulk.

The lateral expansion of the stream divides it into two spirals on the two sides of the axis and separated by it. Along this axis the deposit will be carried farther to sea than on the two sides. This will cause an apparent depression of the sea-bottom opposite the mouths of direct rivers. These depressions have been taken to be submerged river-channels, but they are the natural result of the form of the deposit, except in special cases—of which the Congo may be one. Such depressions may be seen indicated on charts of the sea opposite suitable rivers, as on the west coast of Spain and India, and on the east coast of America.

Original organically formed limestones require not only water free from sediment, which may be found between the openings of large rivers, but an abundant supply of the organisms producing them. It is seen from the results of the *Challenger* expedition that 60 per cent. of the species of such animals, and probably a higher one of the specimens, inhabit the first 100 fathoms, and another 20 per cent. the next 100 fathoms. Limestones are, therefore, most likely to form narrow lenticles with the long axis parallel to the shore, as in the case of barrier reefs; and when we find them giving place to shales, it is not because we are approaching a shore-line, but because in going parallel to the shore-line we are approaching a source of sediment.

VI.—The Evidence of the Hydrothermal Metamorphism of the Schists of South Devon. By A. R. Hunt, M.A., F.G.S.[1]

THE author contends that a dominant cause of alteration in the Devonshire schists was the presence of water; in other words, that as the presence of some degree of heat is not disputed the metamorphism was hydrothermal. He divides the schists into two groups:—

1. Rocks which have been variously called chlorite-schists, hornblende-schists, epidote-schists—or, generally, green rocks.

[1] Abstract of a paper read before the British Association, Belfast, Sept., 1902, in Section C (Geology).

2. Mica-schists, more or less associated with quartz-schists.

The first group are, he observes, usually attributed to the alteration of basic augitic rock; that is, they were originally composed of anhydrous minerals, pyroxenes, and felspars. He then adduces evidence to show that they now have become transformed into rock, consisting of hornblende, epidote, zoisite, and chlorite; all of which contain water of crystallisation, together with albite, which is charged with actual water. In short, he remarks that the one characteristic mineral which by way of addition distinguishes the green rocks from their assumed parents is water.

He then deals with the second group, showing a similar result. Thus, he maintains, the hydro-metamorphism of the district seems pretty well established, and he contends that whilst thermo-dynamic metamorphism is admitted in South Devon, the universal presence of water in the newly constituted rocks must compel us to assign a very important position to hydro-metamorphism as an agent of change. It is not so much that water must have been present during the metamorphic process, as that it is in the rocks now, and could not have been introduced since their crystallisation.

VII.—On the Viscous Fusion of Rock-forming Minerals. By Professor J. Joly, D.Sc., F.R.S., F.G.S.[1]

In a paper read at the Congrés Geologique International of 1900, and in a short note communicated to the British Association Meeting at Bradford, 1900, experiments on the viscous fusion of some rock-forming minerals are described by the author. It appeared that under the influence of prolonged exposure to high temperatures, rounding and other signs of fusion (a breakdown of stability as a solid) could be obtained at much lower temperatures than have hitherto been assigned as the melting-points. This lowering of the melting-point under prolonged heating (four hours) is more marked generally in the case of minerals containing a large percentage of silica, and most marked in the case of quartz. On this account the *order* of the melting-points is in general different under conditions of prolonged heating than under conditions of short exposure.

The former results, as regards melting under conditions of short exposure (results required for comparison with those obtained under conditions of long exposure), were not quite satisfactory (as at the time the author pointed out) in so far that the observations were not effected in the same manner as those under conditions of prolonged exposure. This defect in the observation has now been removed. One-minute exposures have been made of all the minerals previously dealt with on exposures of four hours, and the results confirm the former conclusions, but reveal a decreased difference in the two melting-points; in other words, the short-exposure melting-points being below previous results, the *depression* of melting-point

[1] Abstract of a paper read before the British Association, Belfast, Sept., 1902, in Section C (Geology).

upon prolonged exposure is less than formerly deduced. The depression, however, increases generally with the silica-content of the mineral, as previously observed.

VIII.—On the Valleys at the Head of the Hardanger Fjord, Norway. By Horace Woollaston Monckton, F.L.S., F.G.S.[1]

Above the head of the Hardanger Fjord there is a great moorland with a level of over 2,000 feet. It is an old land-surface of at least pre-Glacial date, with rounded hills and wide shallow valleys. The plateau upon which the snowfield Hardanger Jökul lies and a few mountain tops attain a still higher level, and may, as suggested by Dr. Reusch, be remains of a far older land-surface. In the moorland deep narrow valleys have been cut, probably the result of a rise of the land before or at an early part of the Glacial period. It is suggested that the hollow in which the Hardanger Fjord lies may have been excavated at the time of this elevation.

The author traces the course of the river Bjoreia across the pre-Glacial surface to the Vöringfos (waterfall), where it plunges into the deep narrow valley Maabödal. He agrees with Dr. Reusch that the precise direction of this valley is due to lines of weakness, or cracks in the rock, and that the valley is not a fissure valley, but has been excavated by water assisted by ice.

The author was struck by the resemblance of the head of the valley at the Vöringfos to a giant's cauldron, and suggests that much of the excavating may have been the work of sub-Glacial streams when ice covered the surface. The Maabövand, a talus-dammed lake, is described. Below it the river enters the side of a wide section of the valley, and possibly the head of the valley was at one time at this point. A little below Tveit there appears once to have been a small lake formed by moraine. At Sæbö the valley unites with Hjælmodal, and some interesting terraces are described. Below is the lake Eidfjordsvand, formed by a great moraine. Dr. Brögger has shown that during the early part of the Ice-age the land stood much higher than now. Subsequently depression took place, but towards the close of that period elevation again set in, and the terraces at Sæbö and others below the Eidfjordsvand are the result of this last elevation.

IX.—Note on the Scenery of Ceylon. By A. K. Coomáraswámy, B.Sc., F.L.S., F.G.S.[1]

It is probable that Ceylon has been exposed to continuous denudation since very early Palæozoic times. The foliation of the crystalline rocks has had a marked influence in determining the directions of the river valleys and the general configuration of the country. The foliation strike is usually from north to north-west. Many rivers have a similar direction, as examination of a map will show. A north-and-south strike-valley runs from Wattegama to Dambulla,

[1] Abstract of a paper read at the British Association, Belfast, Sept., 1902, in Section C (Geology).

followed by the railway as far as Matale. North-north-west valleys are conspicuous north of Hunasgiriya. The Mahaweli Ganga valley, south of Peradeniya, is a strike-valley; another good example is the valley running north-west from Hatton. Each of these valleys is followed by the railway. Other conspicuous north-west valleys (probably strike-valleys) are those between Kurunegala and Matale; and north-east of Adam's Peak and south of Ratnapura. A small area east of Kandy has been examined in detail, and shows a diagrammatic system of strike-valleys, with others at right angles thereto, the strike being here, however, more nearly east and west than is usually the case. The bands of limestone may have had some effect in determining the actual positions of these valleys. Of course, *all* valleys in Ceylon are not strike-valleys; thus the Mahaweli Ganga valley crosses the general strike below Gettembe (east of Peradeniya), forming a series of rapids.

A characteristic feature of the scenery of Ceylon in many parts is its precipitous character; the seemingly 'bedded' granulites form mural escarpments and dip slopes, as if they were a series of sedimentary rocks.

The above remarks apply only to the mountainous districts which occupy the south central part of Ceylon. A low coastal plain fringes the island, partly of alluvial and partly of raised beach origin; sea cliffs are absent or very unusual, and even any coast exposures of rock are not common. In the north a greater area is flat and low, and the scenery resembles that of Southern India. Isolated hills of gneiss (Dambulla, Sigiri, etc.) rise conspicuously from the plain.

X.—Short Notices.

1. Oligocene.—No. 15 of Bulletins of American Palæontology (Cornell University), 16 June, 1902, contains the thesis for Ph.D. of Carlotta Joaquina Maury. It is entitled "A comparison of the Oligocene of Western Europe and the Southern United States." Maury's conclusions are: "A comparison of the invertebrate faunas of the two continents offers but little evidence, either for or against the argument, that the Vicksburg and Chipola epochs may properly be referred to the Oligocene. Rather more European Oligocene species or their analogues occur in the American Eocene than in the so-called Oligocene beds. Some also are found in the American Miocene. Yet certain characteristic Oligocene species, or their varieties, are in the Vicksburg and Chipola beds, and as more of the Chipola species are described further similarities may be noted. This incomplete evidence, furnished by the invertebrates, is strengthened by the resemblances found by Scott and others between the vertebrate faunas of the two continents during the period."

2. The Genus *Columbella*.—Mr. S. Pace has completed his list of the described species of *Columbella*. The list, which runs to some two thousand entries, appears in the Proc. Malacol. Soc., vol. v, 1902, and is a preliminary to further study. It is an excellent example

of how to work, as it ensures the acquaintance of the author with his subject; thus standing in striking contrast to the odd and end descriptions of supposed new species, which are poured forth year after year by those who have a meagre acquaintance with literature. It would be interesting to learn how many of these 'species' are valid; perhaps thirty per cent. would be a fair estimate.

3. Polish Geology. — We call the attention of our readers to "Katalog literatury naukowej Polskiej wydawany przez Komisye Bibliograficzna Wydzialu Matematyczno-Przyrodniczego Akademii Umiejetnosci w Krakowie," of which, in part i, there is a list of all the scientific journals published in Polish. The catalogue comes out in parts, and is carried out on the lines laid down by the International Catalogue of Scientific Literature Committee.

4. Australian Tertiaries.—Messrs. Hall & Pritchard publish a suggested nomenclature for the marine Tertiary deposits of Southern Australia in the Proc. Roy. Soc. Victoria, xiv (2), April, 1902. They differ from McCoy, Tate, and Dennant in considering the Balcombian to come above the Jan Jucian and Aldingan beds.

5. Rugby School Museum.—In the Report of the Rugby School Natural History Society for 1901 (1902), a list is given by H. A. Ormerod of the local fossils now on exhibition in the Museum. After each name comes the age and the locality. With the exception of a few Rhætic forms the fossils are all from the Middle and Lower Lias.

6. Surrey Science.—The Presidential Address of Mr. Whitaker, F.R.S., to the Croydon Microscopical Club for 1901 includes a list of papers on the Geology of Surrey for some years past.

7. Stromboli. — In the Archives des Sciences Physiques et Naturelles, xii and xiii, will be found two notes by A. Brun on a geological excursion to Stromboli and a note on its Basalts. The latter paper gives an account of the fusion-point of minerals from this and other localities.

CORRESPONDENCE.

THE GEOLOGICAL SURVEY OF ENGLAND AND WALES AND THE WHITE CHALK.

Sir,—An official memoir on "The Geology of the Country around Southampton (Explanation of Sheet 315)" was received at the British Museum (Natural History) about the 28th August, 1902. In this memoir one reads the extraordinary statement "*Offaster pilula*, an echinoderm characteristic of the *Marsupite* zone" (p. 2, chap. ii, Upper Chalk). If this is true, why is there not some support given to such a statement? It has been distinctly shown by Rowe (Proc. Geol. Assoc., xvi (6), 1900, pp. 342, 363; xvii (1), 1901, pp. 55, 56, 73) that this urchin is characteristic of the *quadratus*-zone, and that its occurrence in the *Marsupites*-zone is extremely unusual.

One would have thought that enough had been said already about the zones of the Chalk, and that especial pains would therefore be taken to attain to greater exactness in official memoirs.

C. Davies Sherborn.

MARINE SHELLS.

Sir,—I beg to inform the readers of the Geological Magazine that, acting under my directions, Mr. David Nimmo, jun., and Mr. Frank White have found *marine shells* in the drift of the Leaze Burn, near the watershed with Logan Water, and four miles north-east of Muirkirk, in Ayrshire. The drift here is a yellowish Boulder-clay, the clay being very fine-grained and exceedingly suitable for preserving organisms. The exposed bed is 15 feet thick, rock not seen, and 1,330 feet above sea-level, and is the highest point in Scotland at which marine organisms have been found in the drift. J. Smith.

Monkredding, Kilwinning.
Sept. 1, 1902.

DEVELOPMENT OF RIVERS.

Sir,—Mr. Buckman, in his article on River Development in the August number of the Geological Magazine, criticizes my paper published in the Quart. Journ. Geol. Soc., vol. lviii, p. 207. On two points his criticisms are well founded. My allusion to the Vale of Moreton, which was added after the writing of the paper, was made under a misapprehension, for I had not grasped the fact that the anticline was considered by Mr. Buckman to be of Inferior Oolite age. Under such circumstances it was of no use to me, for I was in search of an arching up of the Chalk at a much later date. It is true also that the Vale of Moreton is wrongly placed on my map. The name was added, I think, on a proof, but the responsibility, of course, was mine. As regards the other points on which Mr. Buckman considers that I have erred in matter of fact, I see no reason to modify what I wrote.

Mr. Buckman finds it very remarkable that the anticline of which I was in search should be evidenced by no more than traces. The difficulty in locating it is due to the fact that the Chalk, in which alone its effects would have been obvious, has been denuded away; that it has not been recognized in the Oolitic rocks means nothing, for it would be masked by the more pronounced movements which affected those rocks before the deposition of the Chalk, but that it existed is proved by a general consideration of the dip of such Chalk as remains. As I pointed out, the westerly rise cannot have continued indefinitely, for it would have carried the Upper Cretaceous base far above the level at which we believe it to have lain in the West of England and in Wales.

The paper by Mr. Buckman in the Proc. Cotteswold Nat., vol. xiii, p. 175, 1899–1901, which I characterized in a footnote as "transgressing the limits of legitimate speculation," was preceded, as he points out, by a paper in Natural Science, vol. xiv, p. 270, 1899.

In view of his statement that the earlier paper gave his views in more detail, I have turned to it with some interest in the hope of finding further evidence of the changes he describes in the river-system of England and Wales. The paper gives a clear history of the development of a river on a slope composed of rocks of different hardness and porosity, a classification of the breaches which occur in many escarpments, and an exposition of the principles of river-capture, illustrated by examples drawn from different parts of the country. So far the account is excellent, but already an uneasy feeling arises that more evidence for the cases of river-capture quoted as examples would be desirable.

The uneasiness is far from being allayed by what follows. After briefly relating a quarrel between the Thames and the Kennet, as a result of which the former is credited with having appropriated all the Cotteswold streams, the author continues: "The Evenlode was a very large river, draining by one branch the north Welsh mountains, by the other the west side of the Pennine range. East of it was a south-easterly extension of the Dove. The Evenlode soon captured this by sending out the Cherwell as a subsequent stream; and on the other side it captured all the Cotteswold streams. The Kennet was the other important river. It originally drained Mid and some of South Wales."

On the map accompanying these statements the Derbyshire Wye, the Dove, Trent, Mersey, Weaver, Upper Dee, Upper Severn, Teme, Lug, Wye, Usk, Rhymney, and Taff rivers are shown as tributaries of the Thames. Parts of these rivers, it is true, flow in the direction of the Thames, but much of this imaginary river-system crosses the existing lines of drainage at right angles, while such features as the British Channel are got rid of by stating that they did not yet exist. The evidence for the existence of this river-system is of the slightest description; we are told that the rivers must have run thus, and that they must have occupied certain gaps in the Oolitic escarpment. Its restoration seems to have been effected by piecing together such portions of river-valleys as happened to fall into a suitable position on the map.

The Severn is credited with effecting the change to the system now existing. Beginning as a small stream, it captured the Taff, Rhymney, Usk, Wye, and a number of others, its remarkable career being briefly related as a statement of fact. "The further development," the author naively remarks, "may be shortly told." The Severn "started or strengthened two subsequent branches—one northwards, which captured the Shropshire and Welsh drainage, the other north-eastward—the present Warwick Avon which cut off the head-waters of the Thames tributaries from the north."

In his concluding remarks Mr. Buckman is frank. "Many of the statements in this paper may be termed mere speculation. It is fully admitted." I give these brief extracts in justification of my footnote. A. Strahan.

Streatley, Reading.
August 18, 1902.

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No. XI.—NOVEMBER, 1902.

ORIGINAL ARTICLES.

I.—On a Collection of Trilobites from the Coddon[1] Hill Beds, Lower Culm-measures, near Barnstaple, North Devon, and one from Glamorganshire.

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

(PLATE XX.)

HAVING some time since been favoured by Mr. and Mrs. Coomáraswámy (Miss Ethel M. Partridge) and Mr. Joseph G. Hamling, F.G.S., of Barnstaple, with the loan of their collections of Culm Trilobites from Coombe Wood, etc., near Barnstaple, I feel it incumbent to add a few notes to those already published by me in the Appendix to Messrs. Hinde & Howard Fox's paper (Quart. Journ. Geol. Soc., 1895, vol. li, pp. 646–649, pl. xxviii, figs. 1–8).

Out of the large series of specimens kindly sent to me, I have selected and figured on Plate XX thirteen of the best preserved examples from the Coombe Wood section; whilst Figs. 14 and 15 illustrate a nearly entire Trilobite, obligingly lent to me by Mr. Frederick Barke, F.G.S., of Stoke-on-Trent, and obtained by him from beds of reputed Culm age at Bishopston, Glamorganshire.[2]

Phillipsia, sp. (Pl. XX, Figs. 1, 2, and 13 (?).)

Fig. 1 represents the glabella of a *Phillipsia*, with the fixed cheek attached, of the natural size. The glabella measures 16 millimetres

[1] Spelt *Coddon* Hill by H. B. Woodward (Geology of England and Wales), also in the best Gazetteers and on the Geological Map of England and Wales; but *Codden* Hill on the Ordnance Survey Map.

[2] For previous papers on these Trilobites from the Culm, see:—Henry Woodward, "On the Discovery of Trilobites in the Culm-Shales of South-East Devonshire": Geol. Mag., 1884, pp. 534–545, Pl. XVI. H. Woodward, "Carboniferous Trilobites": Mon. Pal. Soc., 1883–84, pp. 1–86, pls. i–x (on the Culm Trilobites, pp. 55–70, pl. x). G. J. Hinde & Howard Fox, "The Radiolarian Rocks in the Lower Culm-measures of Devon, Cornwall, and West Somerset": Quart. Journ. Geol. Soc., 1895, vol. li, pp. 609–668, pls. xxiii–xxviii (Note on the Trilobites, by H. Woodward, pp. 646–649, pl. xxviii, figs. 1–8).

in length, and is 10 mm. in breadth at the posterior border; it diminishes slightly to 9 and 8 mm. respectively, 10 and 11 mm. from the posterior margin, and is marked by three recurved furrows on each side; the hindermost cuts off a small semicircular lobe which is enclosed by it and the latero-posterior angle of the glabella. The glabella is rounded, and does not expand in front; it is separated from the anterior border by the flattened margin of the fixed cheek, which is 3 mm. broad; the fixed cheeks are 4 mm. broad on each side of the glabella, where anteriorly they form a rounded lateral expansion, contracting to 1 mm. in breadth just in front of the eye and broadening to 2 mm. on the superciliary region; thence, after a slight contraction, it again expands to a breadth of 5 mm. at its union with the posterior margin. The nuchal furrow is not very clearly defined and the free cheeks are not preserved.

This glabella and the pygidium, Fig. 12, represent fragments of some of the largest Trilobites hitherto obtained from the Lower Culm of Coddon Hill.

Although much larger in size than *Ph. Polleni*, from the Carboniferous (Culm ?) Shale-beds of the river Hodder, at Stonyhurst (see Geol. Mag., 1894, p. 487, Pl. XIV, Figs. 7–12), I am nevertheless inclined to refer this glabella to that species, possibly also the detached cheek, Fig. 13.

Fig. 2, although smaller (being drawn twice nat. size), probably from its form, may likewise be referred to *Ph. Polleni*.

These fragments may serve to suggest the probable presence of this species at Coddon Hill.[1]

Phillipsia spatulata, sp. nov. (Pl. XX, Figs. 3, 4.)

The head in this species is remarkable for the peculiar form of the cheek-spines, which have a broadly rounded and expanded extremity quite unlike that of any other Trilobite from this locality. The length of the head-shield in Fig. 3 measures 12 millimetres, and the breadth at its base 18 mm. The length of the head to the end of the cheek-spines is 20 mm. These spines extend backwards 8 mm. beyond the base of the head, being nearly 3 mm. broad, and are striated longitudinally upon the under surface. The glabella is 6 mm. broad at its base, the sides are nearly parallel, with a slight expansion and tumescence in front; the fixed cheeks are narrow; they form a border of about 1 mm. in width around the glabella in front. Owing to the state of preservation of these specimens the eyes cannot clearly be made out, but they are about 6 mm. from the posterior border of the glabella; the free cheek is semicircular in outline, with a broad margin which widens perceptibly backwards to the posterior angle, where the spatulate cheek-spine originates.

There are two small triangular lobes at the base of the glabella and a minute tubercle which marks the centre of its posterior

[1] The species hitherto recorded (see Quart. Journ. Geol. Soc., 1895, vol. li, pp. 646–649) are:—*Phillipsia Leei*, H. Woodw.; *P. minor*, H. Woodw.; *P. Cliffordi*, H. Woodw.; *Phillipsia*, ? sp.; *Griffithides acanthiceps*, H. Woodw.; *G. longispinus*, Portl.; *Proetus*, sp. (*a*, *b*).

border; the neck-furrow is not clearly seen in Fig. 3, but a portion is visible in Fig. 4, 1 mm. in width.

Fig. 3 shows an entire head-shield from the Coombe Wood Quarry collected by Mr. A. K. Coomáraswámy, F.G.S., and has a counterpart. Fig. 4 is from Mr. J. Hamling's collection (No. 704) from Overton Quarry. There is also a free cheek and spine (No. 712) from the same collection, Coddon Hill. On re-examining the earlier material in the British Museum (Natural History) I find another very good head-shield and counterpart (registered I. 3215) of this species, presented by Mr. Joseph Hamling, F.G.S., in 1896, from the Culm of Coddon Hill, Barnstaple.

Proetus, Steininger, 1830.[1]

Proetus Coddonensis, sp. nov. (Pl. XX, Figs. 5–11.)

I have spent much time in the examination of these small Trilobites from Coddon Hill, Barnstaple, of which, thanks to Mr. J. G. Hamling and Mr. and Mrs. Coomáraswámy, I have received a large number of specimens. I selected Figs. 5, 8, and 11 as the most perfect examples, the heads Figs. 7, 9, and 10, and the pygidium, Fig. 6, all of which I had reasonable expectations were distinct. I regret to have to admit that my first impressions are not borne out by a more lengthened study of the materials; on the contrary, I am now led to conclude that they must (notwithstanding various minor differences) all be placed in the same species.

These fragmentary remains number about 75 specimens, and consist, for the greater part, of detached heads and tail-shields, only about 21 examples having at least some of the thoracic segments also preserved, 8 only being complete. These Coddon Hill specimens are all extremely small, Fig. 5 being 6 mm.; Fig. 8, 9 mm.; and Fig. 11, $10\frac{1}{2}$ mm. in length.

The head-shield is semicircular; eyes never well preserved, but where visible reniform; glabella slightly broader behind, rounded in front, marked by two triangular lobes at the base; fixed cheeks narrow at sides; glabella separated from margin of shield in front by the smooth or striated border of the fixed cheek. The facial suture which divides the fixed cheek from the free cheek crosses the frontal border just in a line with the eye, above which it expands, forming a rounded palpebral lobe; then passing down close to the line of the axial furrow, it diverges outwards and crosses the posterior border obliquely behind the line of the orbit. Free cheeks roundly triangular, centre of the cheeks raised; margin smooth and broad, produced into a short spine at the posterior angles; neck-lobe corresponding with the free thoracic segments in its axial portion. Free thoracic segments number 7 in Fig. 5, 8 in Fig. 8, and 8 or 9 in Fig. 9. This discrepancy, which I at first regarded as of specific value, if no more, I now conclude to be due to squeezing together of the segments in Figs. 5 and 8, so as to conceal their full number.

[1] For a full description of the genus Proetus see H. Woodward, "Carboniferous Trilobites": Mon. Pal. Soc., 1884, pp. 55–57.

I have detected the *overlapping* clearly in some of the other unfigured examples of this species in the collection, due to squeezing together of the thoracic rings.

Fig. 11 is no doubt the most complete of the three, Fig. 5 having been shortened by squeezing together *longitudinally*, which has given it a greater lateral expansion.

In all these specimens the body axis is considerably broader than the pleuræ, and the trilobation is very strongly marked. The pleuræ are strongly recurved, falcate, and their extremities rounded and broadly faceted.

The pygidium is very short, the axis is truncated and does not reach the posterior border, the coalesced segments are obscure, but appear to be about six or seven in number, the margin when preserved has a well-marked rim (see Fig. 11).

Although in the genus *Proetus* there are several species having a larger number of coalesced segments in the pygidium than are seen in this form from Coddon, yet there are many others with an equally short pygidium. On the other hand, there is *no Phillipsia nor Griffithides* with such a shortened tail-shield, nor can the head-shield, although certainly less well preserved, be referred to either of these genera.

Several forms, at present within the genus *Proetus*, will undoubtedly have to be removed whenever this genus is revised.

Proetus, sp. (Pl. XX, Fig. 12.)

This large pygidium, in which the traces of coalesced segments are almost obliterated, is figured on our plate of the natural size. It measures 29 mm. in width, by 15 mm. in length; the surface is very convex, the axis is 11 mm. broad at its union with the free thoracic segments, and diminishes to 4 mm. near its rounded distal extremity, which almost touches the posterior border. Traces of about two or three coalesced segments can be discerned near the proximal border. The outer margin had a raised thickened rim. The late Professor James Hall, in his "Palæontology of New York," has figured a somewhat similar smooth pygidium, which he named *Proetus crassimarginatus*, from the Upper Helderberg Group (Devonian),[1] but it is longer in proportion to its breadth than is our Coddon Hill specimen. There are no free segments or head-shields known from this horizon which can be relegated to this pygidium; I do not therefore propose to give it a name. It may, for the present, be referred to the genus *Proetus*.

As a large number of these Culm-measure Trilobites are more or less in the condition of compressed and distorted casts, it is often very difficult to determine accurately their minute characters; it is better, therefore, to defer a fuller description of them until, as is to be hoped, more perfect materials are obtained.

Griffithides Barkei, sp. nov. (Pl. XX, Fig. 14.)

This is a characteristic example of the genus *Griffithides*, and may

[1] Pal. New York, 1888, vol. vii, pl. xx, fig. 8.

be compared with *G. longiceps* of Portlock, from the Carboniferous Limestone of Ireland, but the Irish species attains to almost twice the size of Mr. Barke's example from Glamorganshire.

The general outline is ovate-oblong; the glabella is smooth, very gibbous, and pyriform; the basal lobes are rather small and obtusely triangular, and not nearly so prominent as in *G. longiceps*; the axial portion of the neck-lobe is moderately broad, and separated from the glabella by a well-marked smooth furrow; the fixed cheeks are very narrow, but the suture is not distinctly seen in the specimen anteriorly; eyes one-third the length of the head, reniform, surface finely faceted; raised inner portion of free cheeks rather narrow, surface smooth, outer margin wide, posterior angles produced into broad and stout spines, reaching to the 6th segment of the thorax; thorax composed of nine free segments, the axis arched, equalling one-third the breadth of the thorax, each segment of the axis having a row of minute granules along its posterior border, none visible on the pleuræ; angles of pleuræ bluntly terminated (not rounded as in *G. longiceps*); pygidium composed of thirteen coalesced somites, the posterior margin of the axis of each one bearing a row of minute granules, similar to those on the axis of the free segments; axis tapering to the extremity, and rather more pointed and more slender than in *G. longiceps*; ribs nine in number, not granulated, separated from the lateral margin by a broad, striated border, which is widest posteriorly. [The Hypostome.—Fig. 15 on Plate XX represents the hypostome seen *in situ* in the head of Fig. 14. It closely resembles the hypostome of *Griffithides*, see H. Woodward's Mon. Carb. Trilobites: Pal. Soc., 1883, p. 30, pl. vi, fig. 5, which may have belonged to *G. longiceps.*]

Compared with the species nearest to it *G. Barkei* differs from *G. longiceps* in the following particulars:—

The glabella in *G. Barkei* is broader in proportion *anteriorly* and narrower and more pointed posteriorly than in *G. longiceps*; the basal lobes are smaller and much less prominent; the eyes are placed slightly more posteriorly, and abut upon the basal lobes and the neck-lobe; there is no tubercle on the basal lobe; the row of minute granules on the posterior border of each segment is confined to the axis of both the thorax and the pygidium; the pleuræ are bluntly terminated, not rounded; lastly, the ribs in the pygidium do not reach the margin as in *G. longiceps*, but are separated by a broad (striated) margin which widens posteriorly. These differences, together with its much smaller size, suffice to separate *G. Barkei* specifically from *G. longiceps*, than which there is no other so closely related to it. I have much pleasure in naming it after its discoverer, Mr. Frederick Barke, F.G.S., of Stoke-on-Trent.

Concerning the horizon of *Griffithides Barkei*, Dr. Wheelton Hind writes:—"It was obtained at Bishopston, Glamorganshire, from a series of desilicified cherts which rest upon the Carboniferous Limestone massif, and immediately overlying which are beds with fossils of the Pendleside series. These cherts would be very close to the horizon of the beds on the Hodder at Stonyhurst, where

Trilobites occur,[1] and these beds, I strongly suspect, will soon be shown to be of about the same age as the Culm. The number of fossils common to this part of the Culm and Pendleside series is very remarkable: *Posidonomya Becheri, Goniatites* (*Glyphioceras*) *sphæricus, G. spiralis, G. striatus*," etc.

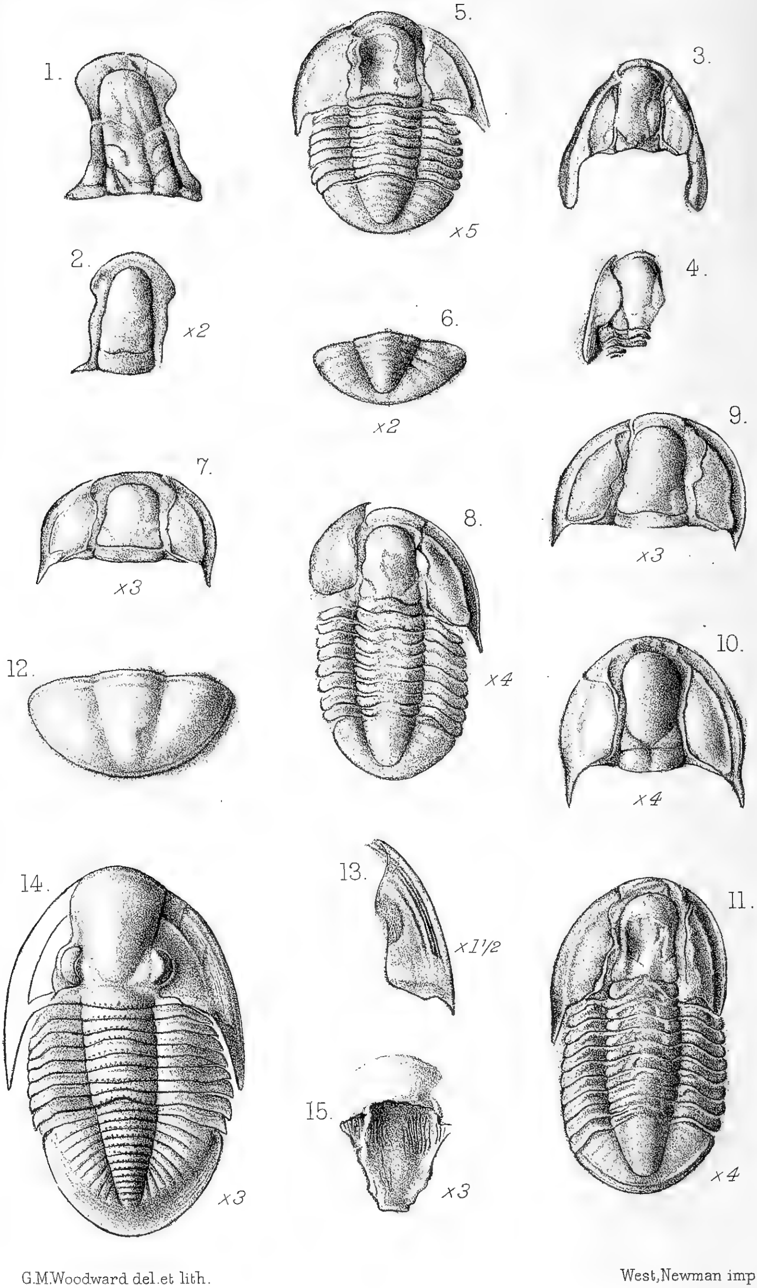
Mr. Horace B. Woodward, F.R.S. (Geology of England and Wales, 2nd ed., 1887, p. 167) writes:—"In Glamorganshire, immediately above the Carboniferous Limestone of Gower, at Penrice, and between Llanrhidian and Oystermouth, there is a considerable development (1,600 feet) of black shales with sandstones, to which the name Gower series has been applied. These beds appear to represent the Upper Limestone shales and perhaps the Millstone Grit. At Tenby they are but a few feet thick, but there they contain beds of dark limestone, and yield *Goniatites*, reminding one of the Black Limestones of North Devon that occur at the base of the Culm-measures." Further on (p. 172) he adds: "The Millstone Grit is not definitely identified in the Gower peninsula, and it remains to be proved whether the Gower shales should be correlated with it, or whether it be represented by certain sandstones above them and now included with the Coal-measures."

So far back as 1846, Sir H. T. De la Beche describes this very section at Bishopston, Glamorganshire, and gives a measured section of the beds. He writes (Mem. Geol. Survey, vol. i, pp. 133 and 143):—

"It is desirable to mention certain beds which occur above the Carboniferous Limestone near Swansea (if, indeed, they may not, in a great measure, be as an upper portion of it), since there is a certain general resemblance between them and the beds in Devonshire immediately above the Pilton Group. When these beds reach the coast in Swansea on the east, the section exposed is not good, and the beds are also concealed where the coastline cuts them towards Caermarthen Bay on the west; but fortunately they can be well studied along the course of the river near Bishopston" (p. 133). (Here follows the section.) He adds further on:—

"At Swansea we observe a development of the black shales and cherty grits above noticed, fining off at Tenby, where we see black limestones with *Goniatites*, the whole of these beds so intervening between the more solid Carboniferous Limestone and Coal-measures appearing as if they were a continuation of the black limestone group of Devonshire, above the Pilton and Petherwin groups, thus extending, locally modified, into South Wales. Under this view the close of the Carboniferous Limestone epoch would, in South-Western England and South Wales, be marked by a mixed deposit of limestone in one part, an alternation of sands, mud, and limestone in another, and by sands, black mud, and Carboniferous limestones in a third" (p. 143).

[1] See H. Woodward, "On a Collection of Carboniferous Trilobites from the Banks of the Hodder, near Stonyhurst, Lancashire": Geol. Mag., 1894, Dec. IV, Vol. I, pp. 481–489, Pl. XIV.



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

Carboniferous Trilobites, *Devon, etc.*

EXPLANATION OF PLATE XX.

FIG. 1. *Phillipsia Polleni* (?). Lower Culm-measures: Coombe Wood, Coddon Hill, near Barnstaple. Nat. size. Mrs. Coomáraswámy's (Miss E. M. Partridge) collection.

,, 2. Ibid. Hannaford Quarry. × 2.

,, 3. *Phillipsia spatulata*, sp. nov. Same form.: Coombe Wood. Nat. size. Mr. Coomáraswámy's collection.

,, 4. Ibid. Overton Quarry. Nat. size. Mr. J. G. Hamling's collection.

,, 5. *Proetus Coddonensis*, sp. nov. Entire specimen. Lower Culm-measures: Coombe Wood, near Barnstaple. × 5. Mr. Coomáraswámy's coll.

,, 6. Ibid., pygidium. Hannaford Quarry. × 2. Mrs. Coomáraswámy's coll.

,, 7. Ibid., cephalon. Coombe Wood. × 3. Coll. ditto.

,, 8. Ibid., entire specimen. Same form., loc., and coll. × 4.

,, 9. Ibid., cephalon. Same form., loc., and coll. × 3.

,, 10. Ibid., cephalon. Same form. and loc. × 4. Mr. J. G. Hamling's coll.

,, 11. Ibid., entire specimen. Same form. and loc. × 4. Mr. Coomáraswámy's coll.

,, 12. *Proetus*, sp., pygidium. Same form.: Hannaford Quarry. Nat size. Mr. Coomáraswámy's coll.

,, 13. *Phillipsia Polleni* (?), free cheek. Same form., loc., and coll. × 1½.

,, 14. *Griffithides Barkei*, sp. nov. Culm-measures (?): Bishopston, Glamorganshire. × 3. Mr. F. Barke's collection.

,, 15. Ibid., hypostome. Same form., loc., and coll. × 3.

II.—*EOPHRYNUS* AND ALLIED CARBONIFEROUS ARACHNIDA.

By R. I. POCOCK, F.Z.S., of the British Museum (Natural History).

(*Concluded from p.* 448.)

PART II.

2. CLASSIFICATION OF *EOPHRYNUS* AND ITS ALLIES.

Several Arachnida allied to *Eophrynus prestvicii* have been discovered in beds of Carboniferous age. Of these the only species known to me as belonging unquestionably to the genus *Eophrynus* that has been properly described and figured is the form from Silesia named *Eophrynus* (in error written *Euphrynus*) *salmi* by Stur.[1] The type is 27 mm. in total length, the prosoma being 8 long and the opisthosoma 19 long and 14 wide. The last-named region is thus considerably narrower in relation to its length than it is in *E. prestvicii*. Apart from this, it is noticeable that the admedian dorsal tubercles, except on the second and third terga, are much smaller than the laterals.

Haase[2] has characterized a third species of *Eophrynus* as *E. sturi*. It is said to be intermediate between *E. prestvicii* and *E. salmi* in having the joints of the lateral tergal laminæ less distinct than in the latter, and more distinct than in the former. Haase's knowledge of *E. prestvicii*, however, was derived from the figure of the type from which the artist omitted the sulci in question. As already described, they are well developed. Hence any inference that is based upon their assumed absence is erroneous. It seems probable that the degree of their distinctness in any given case is more likely to be attributable to the state of preservation of the fossil than to a natural structural variation. Lastly, it appears to me that before the specific distinctness of the three forms that

[1] Abh. k.k. geol. Reich., vol. viii (1877), pt. 2, Vorwort, p. v, with figure.
[2] Zeitschr. deutsch. geol. Ges., vol. xlii (1890), p. 64.

have been described as *prestvicii, salmi,* and *sturi* be unreservedly admitted, the type-specimens must be carefully compared together.

Another species that has been assigned to the genus *Eophrynus* is the form that was described by Dr. Woodward as *Brachypyge carbonis,* the principal synonymy of which is as follows :—

Brachypyge carbonis, Woodw.

Brachypyge carbonis, H. Woodw.: Geol. Mag., Dec. II, Vol. V (1878), pp. 433–6, Pl. XI; id., Bull. Acad. Belg. (2), vol. xlv (1878), No. 4, pp. 410–415, with plate.

Anthracomartus carbonis, Scudder: C.R. Soc. Ent. Belg., vol. xxix (1885), pp. 84–85.

Eophrynus carbonis, H. Woodw.: Geol. Mag., Dec. III, Vol. IV (1887), p. 49 (footnote); Q.J.G.S., vol. lii (1896), p. cix.

This species is represented by eight somites of the opisthosoma, exposed from the dorsal side. The possibility of the correspondence of these to the nine tergal plates of *Eophrynus prestvicii* by the complete fusion of the original second and third to constitute the large second tergal plate of the fossil, has been already discussed (cf. *supra,* Pt. I, p. 444). The somites have the same general form and structure as in *Eophrynus, Kreischeria,* and *Anthracomartus,* but differ markedly in that the edges of the lateral laminæ are emarginate with projecting anterior and posterior angles. This structural modification gives rise to the characteristically scalloped appearance of the borders of the opisthosoma. The latter is wider than long; its central area is raised into an axial elevation due to the development of a bilobed excrescence on each of the terga, that of the second being exceptionally large and recalling the tubercular eminence on the third tergal plate of *Eophrynus prestvicii.* No lateral laminæ are present upon the first or second plates, which were themselves possibly fused; and the last tergum visible on the dorsal side is exceptionally large as compared with the homologous plate in *Eophrynus prestvicii.*

Nearly allied to but apparently quite distinct from the foregoing species is the following, to which I am compelled to give a new name :

Brachypyge celtica, sp.n.

Eophrynus carbonis, Howard & Thomas: Trans. Cardiff Nat. Hist. Soc., vol. xxviii (1896), pt. 1, pp. 1–2, figs. A and C. (*Nec* Woodward.)

This species is also represented only by the opisthosoma; but although the ventral surface instead of the dorsal is exposed, it presents three characteristics in which it differs markedly from the opisthosoma of *B. carbonis,* Woodw. In the first place it is much wider than long, in the second place the second somite is considerably wider than the first, and in the third place both the first and second somites are furnished with lateral laminæ similar in form to those of the somites that follow.

It consists of nine somites, in addition to the anal valve. The first and second show very distinctly the impression of the missing coxa and trochanter of the last appendages of the prosoma, which were overlapped by their laterally expanded dorsal area. There is an angular depression in the middle of the posterior half of the sixth and seventh, and a narrow transverse depression, identified by the describers as a stigma, on the posterior border of the lateral portion of the third, fourth, fifth, sixth, and seventh somites. The lateral laminæ and the sides of the last somite are conspicuously pitted.

The type-specimen of *Brachypyge carbonis* was originally described, in 1878, by Dr. Woodward as the abdomen of a Brachyurous Decapod Crustacean, to which in a general way it certainly bears a resemblance. Geinitz, and independently Scudder, were the first to suggest its probable Arachnid nature. This suggestion was subsequently adopted by Dr. Woodward.[1] Haase, however, who in 1896 published his critical revision of the Carboniferous Arachnida, rejected the later view, and, readopting in substance Dr. Woodward's original supposition, held the specimen to be the abdomen of an Anomurous Crustacean allied to *Lithodes*. That Geinitz and Scudder were right, is shown, I think, by the discovery by Howard & Thomas of the species here named *Brachypyge celtica*, which is certainly referable to the same section of the animal kingdom as *Anthracomartus* and *Eophrynus*, and at the same time shows great similarity to *B. carbonis*.

The fossil described as *Kreischeria wiedei* by Geinitz[2] is obviously nearly related to *Eophrynus*, as has been insisted upon by Scudder[3] and Haase.

Although the tubercles are fewer in number and restricted to the median portion of the terga, the opisthosoma is in a general way practically identical structurally with that of *Eophrynus*, even to the presence of a spiniform process upon the posterior angle of the lateral lamina of the seventh and eighth terga. The question of the homology of the anterior terga has been already discussed. It may be added, however, that although the second tergum is longer than the first or third, its median tubercles are absent instead of enlarged as in the third tergum of *Eophrynus*. The carapace, too, is very similar to that of *Eophrynus*, though less corrugated. Its median area is elevated, and its lateral area transversely grooved and horizontal. There is this difference, however, between the two. In *Kreischeria* the posterior horizontal area is considerably longer than in *Eophrynus*; the central fovea extends forwards as a long and deep groove past the middle of the elevated area, which is sharply constricted in its anterior portion. The area in front of the constriction is about as wide as long, and bears a pair of large eyes in its centre. Movably attached to its fore margin, there is said by Haase to be a separate transverse skeletal piece. The presence of this frontal sclerite in *Kreischeria* and its apparent absence in *Eophrynus* were the main characters upon which Haase relied in referring these genera to different families, the Kreischeriidæ and Eophrynidæ. Considering, however, how closely related the two are in other respects, I cannot, without further evidence, believe in the reality of this difference,

[1] See H. Woodward, Presidential Address to the Geological Society, 1896, vol. lii, p. cix.
[2] Zeitschr. deutsch. geol. Ges., vol. xxxiv (1882), p. 238, pl. xiv.
[3] Proc. Amer. Acad. Arts and Sci., vol. xx (1885), p. 17.

and must hold that if this frontal plate was present in *Kreischeria* it was also present in *Eophrynus*; and, conversely, if it was absent in *Eophrynus*, as appears to be the case, Haase probably put a wrong interpretation upon the structure he described as a separate 'Stirnschild.' In short, I see no reason for dissenting from Scudder's view that the two genera belong to one and the same family.

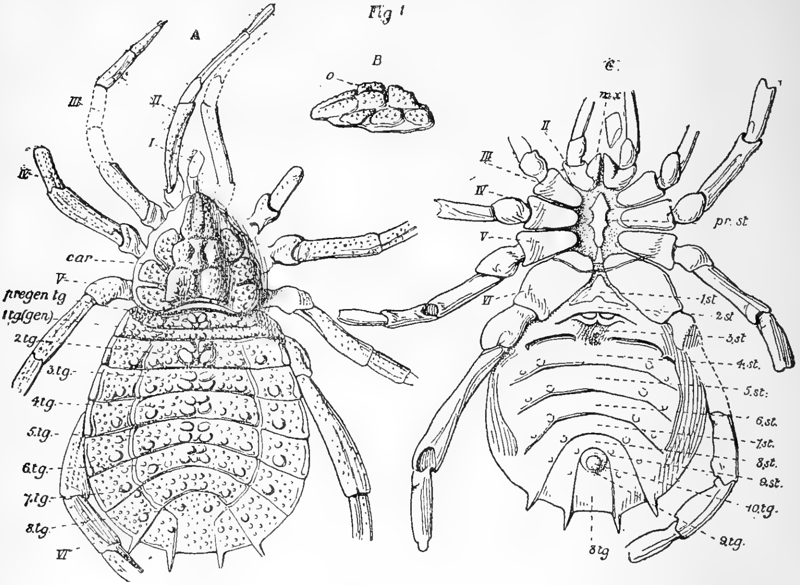


FIG. 1.

A.—Dorsal surface of *Eophrynus prestvicii*. I–VI, appendages of the prosoma; *car.* carapace; *pregen. tg.* tergum of pregenital segment; 1 *tg.* (*gen.*) tergum of first or genital segment of opisthosoma; 2 *tg.* – 7 *tg.* terga of second, seventh, and intervening segments with movable lateral laminæ; 8 *tg.* tergum of eighth segment with movable lateral laminæ and immovable posterior median lamina.

B.—Lateral view of carapace, the anterior extremity to the left, the posterior to the right. *o.* 'ocular' pit on the median lobe.

C.—Ventral surface. II–VI, coxal segments of the post-oral appendages of the prosoma, those of the second pair (palpi) bearing the maxillary process (*mx.*); *pr. st.* sternal area of prosoma with median sternal plates and lateral membranous area; 1 *st.* sternal plate of first or genital segment of opisthosoma; 2 *st.* ditto of the second segment, with paired lobes; 3 *st.* ditto of third segment, with median depression and laterally elevated posterior border; 4 *st.*–8 *st.* ditto of the fourth, eighth, and intervening segments, with paired tubercles; 9 *st.* ditto of the ninth or pre-anal segment; 8 *tg.* lower surface of median lamina of tergum of eighth segment; 9 *tg.* tergal area of ninth segment; 10 *tg.* anal operculum or tergal plate of the tenth segment.

Provisionally, at all events, I think *Brachypyge* may be allowed to stand as a distinct genus. It has been dropped as a synonym both of *Eophrynus* and *Anthracomartus*, without the certainty of its identity with either. Indeed, until the structure of the prosoma is known, the genus cannot with assurance be referred either to the Eophrynidæ or Anthracomartidæ. The two species here assigned to it resemble each other, and differ from the known forms of the other genera in certain characters of which the value cannot accurately be assessed on account of scarcity of material wherewith to test their constancy. Pending the discovery of this desirable addition to our knowledge, it is a matter of indifference whether we classify *Brachypyge* with the Anthracomartidæ or Eophrynidæ.

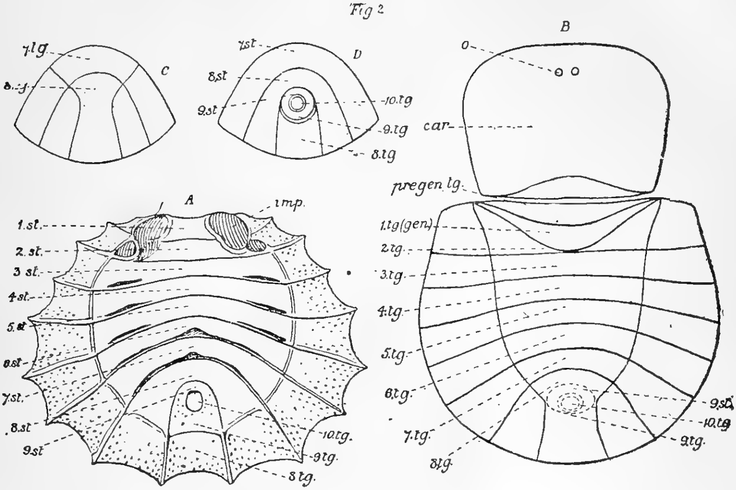


FIG. 2.

A.—Ventral view of opisthosoma of *Brachypyge celtica* (after Howard & Thomas), with lettering as in Fig. 1, *C*, with the addition of *imp.*, marking the impression of the coxa of the sixth appendage.

B.—Dorsal view of *Anthracomartus palatinus*, after Ammon. *car.* carapace; *o.* eyes. Lettering of the opisthosoma as in Fig. 1, *A* and *C*, the segments marked 9 *tg.*, 10 *tg.*, and 9 *st.* indicated by dotted lines to show their position beneath the eighth segment with its lateral movable and median immovable laminæ (8 *tg.*).

C, D.—Dorsal and ventral views of posterior end of opisthosoma of *Anthracomartus völkelianus*, Karsch (after Haase). Lettering as in the foregoing figures.

The following table will perhaps, as well as another, represent the affinities of the genera:—

a. Carapace with its dorsal area flattish or evenly convex from side to side, undifferentiated into a median elevated and a lateral horizontal area, and without strongly marked median and lateral muscular impressions. Fam. ANTHRACOMARTIDÆ.

- a^1. Free edges of the lateral tergal laminæ of the opisthosoma concave, with projecting spiniform angles ... ... *Brachypyge*, Woodw.
- b^1. Free edges of the lateral tergal laminæ evenly convex, forming a continuous curve ... ... *Anthracomartus*, Karsch.

b. Carapace with its dorsal surface differentiated into a median elevated area and a horizontal lateral area; the median and lateral muscular impressions deep; edges of tergal laminæ of opisthosoma convex as in *Anthracomartus*, but the posterior angles of the seventh and eighth spiniform ... Fam. EOPHRYNIDÆ.

a^2. Carapace with its posterior horizontal area short, the median muscular fovea forming an angular notch in the posterior border of the elevated area. *Eophrynus*, Woodw.

b^2. Carapace with its posterior horizontal area relatively long, the median muscular fovea forming a deep longitudinal groove extending forwards past the middle of the median elevation ... ... *Kreischeria*, Gein.

With the genus *Anthracomartus* it is needless here to deal. So far as I know, it chiefly differs from *Eophrynus* and *Kreischeria* in the structure of the carapace, which, instead of being mesially elevated and laterally horizontal and grooved, has a flattened or slightly convex undifferentiated dorsal surface. A pair of small median eyes has been detected by Ammon in *A. palatinus*.

3. Taxonomy of the Anthracomarti.

Of the various attempts that have been made to classify these Carboniferous Arachnida and to give them their true position in the class to which they belong, Haase's is unquestionably the most successful.

Scudder included such heterogeneous elements under the Anthracomarti that no satisfactory definition of the order was possible. Moreover, he severed *Anthracomartus* from *Eophrynus* and *Kreischeria*, classifying it with *Geraphrynus* and *Architarbus* under the Architarbidæ, and thus failed in his diagnosis of both families. Haase, on the contrary, recognized the close relationship between *Eophrynus*, *Kreischeria*, and *Anthracomartus*, and rightly restricted the term Anthracomarti to these three genera.

His appreciation also of the affinities between the Anthracomarti and recent Opiliones was a great advance in the taxonomy of fossil Arachnida. It may be doubted, however, whether his classification of the Opiliones into the four suborders Phalangiotarbi, Anthracomarti, Laniatores, and Palpatores is one that represents in a true light the affinities between the forms included. On the position of Phalangiotarbi I do not wish to give an opinion until an examination of the fossil is possible; but it seems to me that what we now know of the Anthracomarti justifies the conclusion that *if* this group be included in the Opiliones it must be given a rank equivalent to the Laniatores, Palpatores, and Anepignathi or Cyphophthalmi — the Opiliones veri — taken together. These three suborders are distinguished by the sum of a number of characters, many of which, such as the armature of the palpi, the numbers of claws on the legs, etc., admit of exceptions, and no one of which is perhaps in itself of subordinal value. On the other hand, they resemble each other and differ from the Anthracomarti in certain structural features of sufficient taxonomic importance to admit of their association in one group, which may be termed the Phalangiomorphæ, equivalent to the Anthracomarti.

The two may be distinguished as follows:—

a. The prosoma and opisthosoma not immovably welded together, but freely articulated to one another, as in all the primitive types of Arachnida. The segments of the opisthosoma also apparently jointed by flexible arthrodial membrane. The lateral margins of the terga produced into large laminæ, secondarily divided by a joint-forming sulcus from the central portion of the somite. Basal segments

of the third, fourth, and fifth pairs of appendages movable and separated by a wide sternal area, which was membranous at the sides and furnished with a median longitudinal sternal plate, extending anteriorly between the coxæ of the appendages of the third pair (first pair of walking-legs).
ANTHRACOMARTI.

b. Prosoma and opisthosoma not movably jointed together, and at least the anterior four somites of the opisthosoma fused. Lateral portions of terga and sterna of opisthosoma not produced into movably jointed laminæ. Coxæ of the posterior appendages free or united to the prosoma, the sternal region of which is reduced to a narrow longitudinal sclerite by the encroachment of the appendages towards the middle line, or to a short transverse plate by the forward movement of the sternal elements of the anterior somites of the opisthosoma ... ... PHALANGIOMORPHÆ.

But whether the definition of the Opiliones be extended to include the Anthracomarti or whether the latter be regarded as an order apart, are questions of subordinate importance. The chief interest attached to these Carboniferous Arachnida lies in the fact that, setting aside the development of the specialized tergal laminæ, the characters in which they differ from the Opiliones serve to link the latter to the Pedipalpi. The fusion of the prosoma with the opisthosoma, and of more or fewer of the tergal plates of the latter region with each other; the reduction in number of the segments of the opisthosoma to ten, including the anal valve, or eight; the immobility of the coxæ of the appendages and their admedian approximation on the lower side of the prosoma, accompanied by the reduction in size of the sternal sclerite, are a few of the many specialized features of the Opiliones. But since the Arachnida of this order are descended from forms in which the opisthosoma consisted of twelve separately jointed segments and was movably articulated to the prosoma, and in which the appendages of this region were freely movable and were separated by a broad sternal area furnished with a large sternal plate or plates, the existence of forms antecedent to the Opiliones and occupying an intermediate position between them and the primitive type is a necessity demanded by the theory of descent. The nearest known allies to these antecedent forms are, I believe, the extinct Arachnida belonging to the Carboniferous Anthracomarti.

III.—THE BASALT OF THE MOABITE STONE.

By Professor T. G. BONNEY, D.Sc., LL.D., F.R.S.

A BLOCK of basalt, bearing an ancient inscription in a Semitic language, was discovered in 1868 at Dhiban (the Dibon of Scripture) by the Rev. F. A. Klein, of the Jerusalem Mission Society. This block, which measured 3′ 10″ × 2′ 0″ × 1′ 2·5″, proved on examination to have been erected by Mesha, King of Moab about 890 B.C., and to refer to the war mentioned in 2 Kings iii. A series of blunders on the part of those anxious to obtain this interesting relic caused a quarrel about ownership between two Arab tribes, and one of them, to spite the other, broke it in pieces. These, however, were obtained by the French Consul in Palestine, and sent to Paris, where they were fitted together so far as possible, and the repaired stone is now in the Louvre Museum.[1] The late Professor E. H. Palmer, on a visit to Dhiban in 1870, picked up a small fragment from those still lying on the spot, which he gave to me on his return to England. The constant pressure of other work has hitherto prevented me from examining the specimen, and I have only recently had a slice prepared. The largest face of the fragment measures about 3″ × 2·5″, but the thickest part hardly exceeds half an inch. The original smoothed surface of the stone, possibly including part of a letter, may be seen on one of the sloping sides.

The rock apparently is in good preservation; minutely granular, nearly black in colour, but proving on a closer examination to be speckled with more than one dark mineral, and with less definite greyish spots, all very small. Its specific gravity (by a Walker's balance) is 2·89. The slice, when examined under the microscope, exhibits a porphyritic structure, though on a small scale, no one of the minerals exceeding about ·05″ in diameter. They are:—(*a*) Augite, not abundant, brown in colour, the grains presenting a rather corroded aspect both externally and even internally, partially including, in one instance, a small grain of the next mineral. (*b*) Olivine, rather abundant, rounded or slightly irregular in outline, occasionally showing a fairly well-developed brachypinacoidal and an imperfect macropinacoidal cleavage. A brown staining has affected the exterior of most grains, and penetrated for a short distance into cracks. This, in addition to a very faint yellowish tinge in the grains, shows the olivine to be a rather ferriferous variety. (*c*) Iron-oxide, hematite, or perhaps ilmenite, with a rusty-looking exterior; (*d*) felspar: this, like the last-named mineral, varies so much in size that it is difficult to draw the line between crystals occurring porphyritically and those in the base. In no case do the extinction angles give very decisive evidence, but they suggest that labradorite is at any rate the dominant species.

The minutely holocrystalline groundmass, except for one or two small patches, consists of lath-like plagioclases, up to about ·004″ in length; of stumpy, not very well-formed prisms of brown augite, about ·002″, and of granules of iron-oxide. The patches, small[2] and not numerous, are formed by a fairly clear mineral, which, however, includes some very minute films, giving bright polarization tints, its own being very low, not rising above a greyish or slightly pinkish white. Each patch generally consists of two or three grains, and is without a definite external form. The small felspars and augites are sometimes included by or project into these patches from the surrounding matrix, which has no regular boundary. The mineral resembles a lime carbonate (there is no distinct cleavage), and I observed, on applying some hydrochloric acid to the cut surface, a rather brisk effervescence at a number of points; hence, I conclude it must be calcite, probably not very pure. But though it occurs

[1] Palmer: "Desert of the Exodus," pt. 2, ch. x. For the inscription see Ginsburg, "Moabite Stone." A figure and succinct account are given in Chambers' Encyclopædia, s.v. Moabite Stone.

[2] The diameter of the largest is about ·03″.

sporadically it does not seem to fill a cavity, or to have replaced a less stable species of felspar, which indeed, as the rock is in good preservation, is hardly probable. So I think the mineral must have been present as a constituent when the rock was molten, and can only suppose that the latter, on its ascent to the surface, caught up some intervening limestone, and the pressure sufficed, as in a case of contact metamorphism, to prevent the dissociation of the carbonate, which here and there retained its identity in the viscid mass.[1] This occurrence in such a rock as basalt, is, I think, rather unusual.

IV.—The Cenomanian Overlap.

By A. J. Jukes-Browne, B.A., F.G.S.

THAT the Upper Cretaceous deposits overlap those of the Lower Cretaceous series, and extend over much larger areas throughout the whole of western and central Europe, are facts which have long been familiar to all European geologists. There has, however, been a tendency, especially in France, to imagine that the subsidence to which the overlap is due took place at one particular epoch, namely, the Cenomanian, and that this subsidence was so rapid and profound that it caused the Upper Cretaceous Series to be sharply marked off from the subjacent strata by the so-called 'Cenomanian transgression.'

Moreover, some French geologists so magnified the importance of this transgression that they regarded it as a criterion for deciding whether a given stage or zone should be classified as Lower or Upper Cretaceous. Their views have doubtless had much influence upon Continental opinion, and are largely responsible for the classification which places the 'Albian' in the Lower Cretaceous Series, and for the uncertainty as to whether the zone of *Am.* (*Schlœnbachia*) *rostratus* should be grouped with the Albian or the Cenomanian.

In England there has never been any such doubt; we have always included the Gault (Albian) in the Upper Cretaceous Series, and have regarded it as partaking in the transgression of that series beyond the limits of the Vectian or Lower Greensand.

The French view dates from the time of D'Orbigny, who wrote in 1840 as follows:—"From the time of the craie chloritée (which he afterwards called Cenomanien) we see that the whole aspect of the Cretaceous seas was changed. . . . At about this epoch the extension of the seas both in France and throughout Europe was at least double that which they had at the time of their first invasion of the region in the Neocomian period." This generalization may have been in accordance with the knowledge of D'Orbigny's time, but is not maintainable in the light of more recent investigations. It should be remembered that when D'Orbigny thus wrote, and for many years afterwards, he believed that there was a marked discordance between the Albian and the Cenomanian deposits, and that

[1] For cases of the imperfect digestion of a carbonate in an igneous mass, see J. Parkinson, Q.J.G.S., lvii (1901), p. 198, and A. K. Coomáraswámy, id., lviii (1902), p. 399.

no representative of the former existed on the coast of Normandy nor in the departments of Orne or Sarthe. We now know that there is no such discordance, only an overlap, and that the Albian (both as Gault and Gaize) occurs in Normandy as well as in the Orne.

It is therefore satisfactory to find that some French geologists are beginning to see that the Cenomanian transgression was only part of a general Cretaceous transgression, which was due to a great and continued subsidence, and not to a specially extensive subsidence at the beginning of Cenomanian time. M. de Grossouvre, in a paper read at the meeting of the French Association for the Advancement of Science in 1901, has protested against the accepted view of the 'Cenomanian transgression,' and his remarks are so decisive that they deserve a larger audience than that to which they were specially addressed. From them I quote the following translated paragraphs:—

"To begin with, it is essential to point out that this transgression was not a sudden and almost instantaneous phenomenon, and that on this account it cannot be considered as a disturbance of a definite date furnishing everywhere a clearly-marked point of departure.

"Let us examine, for example, what happened in the northern and central parts of Europe. We know that large areas were raised into land toward the close of Jurassic time; then with the opening of the Lower Cretaceous era we perceive the sea advancing from the Mediterranean region to invade by degrees the territories which it had temporarily abandoned. In one place it is the *Spatangus* limestones (Neocomian) which rest on the Jurassic; in another it is the sands with *Am. Milleti*, or the clays of the zone of *Am. mammillaris*; elsewhere it is the zone of *Am. inflatus* which commences the transgressive series.

"This slow and continued progress of the invasion of the continental area by the sea is observable not only in northern and central Europe, but can be traced in nearly every part of the globe. . . . [References are here given to the transgression in North America, Brazil, and West Africa.]

"I content myself with these few examples, which it would be easy to multiply, and from the above statements I think I may safely draw the conclusion, that the Cenomanian transgression represents only one phase or episode in a long period of slow and continued transmutation, which can be followed from the very dawn of the Cretaceous era. Moreover, the movement did not stop with the Cenomanian epoch, and I could show that it was continued up to the end of Campanian time (Upper Senonian).

"It has been said that at the epoch of the *Am. inflatus* beds it was so pronounced that it constitutes by this very circumstance an exact chronological datum which can everywhere be recognized. This in my opinion is another mistake, for if at many points the beds with *Am. inflatus* are seen in transgression over the older deposits, in many other places we can see the free Cenomanian resting directly on the Jurassic and sometimes on the Primary rocks. Is it not so at Mans, where D'Orbigny took the type of his stage? In Aquitaine, at Essen in Westphalia, in Bavaria, in Saxony, Bohemia, Galicia, and over the greater part of the Russian platform, the base of the overlapping Cenomanian does not show any trace of the beds with *Am. inflatus.*"

By the "free Cenomanian" he clearly means the upper or true Cenomanian, free from the zone of *Am. rostratus* (*inflatus*); the zone of *Am. varians* having overlapped that of *Am. rostratus,* just as the latter has overlapped the Lower Gault with its zones of *Am. interruptus* and *Am. mammillaris.* He concludes by showing that the generality of the special Cenomanian transgression has been much exaggerated; that Cenomanian deposits are absent in some parts of France, Switzerland, Spain, North Africa, and America; and that subsidence of one region has generally been compensated by the upheaval of some neighbouring region.

We may hope that this vigorous protest will go far toward dispelling the false conception of a special Cenomanian subsidence and transgression which has so long been one of the fixed opinions of Continental geologists. The transgression exists, but should be described as the Cretaceous, not the Cenomanian, transgression.

It may well be that the extent of surface gained by the sea of the Cenomanian or Lower Chalk age in Europe was greater than that gained during any previous stage of the Cretaceous period, but the extent of such an invasion of the sea depends not only on the amount of vertical subsidence but also on the slope of the area invaded; thus a subsidence which would carry the sea only 20 yards up a steep slope might carry it 20 miles over a fairly level plain. It is therefore very probable that those regions where Cenomanian deposits form the basement-beds of the Cretaceous Series over a large extent of country were broad terrestrial plains during the formation of the earlier Cretaceous strata; and that the subsidence which carried the sea over them was not more rapid nor vertically greater than the subsidence which occurred in the preceding Selbornian stage or in that of the succeeding Turonian.

V.—Notes on the Fossils of the Silurian Area of North-East Ireland.[1]

By R. Clark, Esq.

It would be difficult after the closest investigation to add much to the exhaustive list of species given in the excellent paper on this subject which was read by Mr. Swanston before the Belfast Naturalists Field Club some twenty-five years ago. In that paper reference is made to the classification by the Geological Survey of the rocks of the district, under the general heading of Lower Silurian. Subsequently to the publication of the maps of the area, the information as to the Silurian fauna was greatly extended by the labours of Professor Lapworth and Mr. Swanston, to whom science is so largely indebted. The

[1] Read before the British Association, Belfast, Sept. 1902, in Section C (Geology). Communicated by permission of the Director of the Geological Survey.

completion of the *one-inch* Geological Map of Ireland enabled the revision of work done in the earlier stages of the Survey's existence to be undertaken, and in this revision the North-East Silurians were amongst the first dealt with, and I was detailed to search the most promising localities for fossils, and to zone the beds in which they might occur.

This work was proceeded with until not only the North-East area but the Southern Silurian districts also were gone over; and a comparison of the old series of maps and the revised editions which have been published within the past few years will show that the results of the collections made have necessitated very considerable alterations in the original mapping.

Taking Coalpit Bay, Donaghadee, as a starting-point, this prolific though circumscribed little area, afforded a key to the vast proportion of the Silurian beds which with slight interruption extend southwards to the Atlantic on the Waterford coast; and although in few other localities was the same wealth of fauna of different horizons met with, it was interesting to recognize in numerous new localities the occurrence of forms which enabled a ready recognition of the exact position of the beds, most of which were typically represented in the regular sequence of Coalpit Bay.

As some time must elapse before revised explanations to the new editions of the maps will be forthcoming, brief notices of new or hitherto unrecorded species, gaps filled up, and new localities may be interesting and useful.

In the district covered by Mr. Swanston's paper it will be sufficient to mention a couple of localities, new or hitherto unreferred to. First I would mention a section cut through by a small stream at Lissan, near Saintfield (Sheet 37), from which a number of specimens indicative of Lower Hartfell (Caradoc) beds were obtained; these were mostly in a state of excellent preservation, and amongst other species were the following:—

Diplograptus foliaceus.
,, *mucronatus.*
,, *truncatus.*
Climacograptus Scharenbergi.
Leptograptus flaccidus.
Pleurograptus linearis.
Glossograptus Hincksii.
Dicellograptus elegans.
,, *Forchammeri.*
,, *Morrissi.*
,, *Moffatensis.*
Dicranograptus ramosus.
Corynoides calcularis.
Siphonotreta micula.

The second locality is a small quarry in Holywood Glen (Sheet 29), which yielded a number of species characterizing this locality as the Glenkiln horizon (Upper Llandeilo); principal amongst the forms which occur here in easily recognizable condition being—

Cœnograptus gracilis.
,, *circularis.*
,, *pertenuis.*
Thamnograptus typhus.
Glossograptus Hincksii.
Climacograptus Scharenbergi.
Climacograptus bicornis.
Dicellograptus intortus.
,, *sextans.*
,, *Moffatensis.*
Dicranograptus ramosus.

The absence of *Rastrites maximus, Dicellograptus anceps,* and *Pleurograptus linearis* having been commented on by Messrs. Swanston and Lapworth, it is satisfactory to record that I have since found these forms, the first-named at Tieveshilly, the second in a pocket of black slate in greenish mudstone at Coalpit Bay, whilst *Pleurograptus linearis* was collected from the locality at Lissan previously referred to.

A unique specimen from the Lower Birkhill (Llandovery) beds of Coalpit Bay claims attention. It has been identified by Mr. E. T. Newton, F.R.S., as *Berwynia Carruthersi,* a Lycopodiaceous plant, originally described by Dr. Hicks from Pen-y-glog (Q.J.G.S., vol. xxxviii); it had not hitherto been recognized in Ireland.

Passing from what may be styled the Belfast immediate area towards the south and south-west, some ten additional fossiliferous localities were added to those already recorded. From the district comprised within Sheet 48, they were, with one exception, all indicative of the Middle or Lower Birkhill (Llandovery) horizon, and, save from one locality, Lough Erne, on the north-east margin, which yielded eight species of Graptolitidæ, the specimens obtained were not well preserved.

The Armagh district (Sheet 47) afforded good and interesting collecting ground, though no fossils from the Silurian beds appear to have been previously recorded. A close examination disclosed numerous localities in both upper and lower strata, ranging from Lower Llandovery to Upper Llandeilo, this latter zone being well represented a little north of Poyntzpass by the occurrence of—

Dicellograptus Moffatensis.	*Dicranograptus ziczac.*
,, *sextans.*	*Diplograptus bimucronatus.*
,, *Forchammeri.*	*Cœnograptus gracilis.*
,, *truncatus.*	*Climacograptus Scharenbergi.*
Didymograptus superstes.	*Siphonotreta micula.*

These forms were found in the black carbonaceous, cherty band generally associated with this particular horizon.

Within the radius of Sheets 58 and 59, more especially in the north-east corner of the latter, finely preserved specimens of Upper Llandovery Graptolites were found in the railway cuttings close to the tunnel on the Newry and Armagh Railway, whilst in the vicinity of Castleblayney both Llandovery and Caradoc specimens occur in numerous places. In Sheet 58 *Cœnograptus gracilis* was noted in the railway cutting east of Newbliss, indicating Upper Llandeilo.

Sheet 69 afforded substantial additions to the list already published therefrom. Graptolites were procured from some twelve additional localities, and from many of these the specimens were obtained in excellent preservation; in this respect those from Killyrue, four miles south-east of Cootehill, are specially worthy of mention.

The known localities for Silurian fossils on Sheet 80 have been much increased, and good specimens obtained of Lower Caradoc and Llandovery species; of the former *Diplograptus foliaceus,* *Dicellograptus*, and *Pleurograptus* were indicative, whilst the higher zone is distinguished by such as *Monograptus convolutus* and *M. tenuis*, as also *Diplograptus folium*, or *palmeus*, which is somewhat rare outside the Coalpit Bay district.

The fossils of the Silurian rocks of Sheet 81 are dealt with rather fully in the memoirs of that and the adjoining Sheet 91, in which latter the district of Slane afforded a rich harvest of forms ranging from Llandeilo to Wenlock. Sheet 82 had been hitherto regarded as a barren area so far as fossils were concerned; however, a close search disclosed at a couple of localities near Clogher Head the existence of the zone of *Monograptus exiguus*, or top of Upper Llandovery, and in addition to *M. exiguus* beautifully preserved specimens of *Monograptus attenuatus*, *crispus*, *proteus*, and *lobiferus* were procured; indeed, at no other locality save Tieveshilly were the same peculiar forms observed.

VI.—A (Preliminary) List of the Minerals occurring in Ireland.[1]

By Henry J. Seymour, B.A., F.G.S.

The literature dealing with Irish mineralogy is rather extensive, much more so than might be at first thought, but it is of such a scattered nature that to obtain at present anything like a complete account of the minerals which occur in this country, or in any particular portion of it, would involve much time and labour in hunting up the publications containing the various records. The need of some authentic work of reference on the subject, revised to date, was often felt by the writer, who some years ago set to work to collect together all the data available, both from published records and by means of a personal examination of such public and private collections of minerals in this country as he could gain access to.

This research is not yet complete, but the publication last year of a list of Scottish minerals at the British Association meeting in Glasgow has induced the writer, in view of the meeting of the same Association in Belfast this year, to publish a *preliminary* list of Irish minerals. This list comprises the various species which up to the present he is satisfied may be regarded as undoubtedly occurring in Ireland. References were made to the lists of Irish minerals which have already been published, the last in 1868. These have appeared as appendices to lists from other localities, and in publications now out of print. G. H. Kinahan's publication (Economic Geol. of Ireland) dealt solely with metallic ores and a few other economic minerals. In the account which the writer hopes to have ready for publication within a year, the occurrence of Irish minerals only will be mentioned, together with other important details of interest, and

[1] Abstract of a paper read before the British Association, Belfast, September, 1902, in Section C (Geology).

accompanied by analyses when obtainable. It is also contemplated to add a Bibliography of Irish Mineralogy. In the above respects it will therefore be the first publication of its kind in this country; and the chief aims of its compiler are: to encourage the study of a much neglected science in Ireland; to prevent the possibility of anyone announcing as 'new finds' minerals recorded more than twenty years ago, instances of which have come to the notice of the writer in the course of his work; and to prevent the waste of energy involved in re-examining well-known localities, to the neglect of others much more promising and quite unworked.

The following is the preliminary list of Irish minerals above referred to; and the further work which the writer hopes to do during the coming year will doubtless add many more species to the list, and perhaps also lead to the removal of a few which now find a place therein.

Graphite.
Sulphur.
Gold.
Silver.
Copper.
Stibnite.
Molybdenite.
Galena.
Chalcosite.
Blende.
Pyrrhotite.
Bornite.
Chalcopyrite.
Pyrites.
Cobaltite.
Marcasite.
Arsenopyrite.
Tetrahedrite.
Geocronite.
Halite.
Fluor.
Quartz.
Tridymite.
Opal.
Water.
Cuprite.
Corundum.
Hæmatite.
Ilmenite.
Magnetite.
Cassiterite.
Rutile.
Octahedrite.
Brookite.
Pyrolusite.
Manganite.
Limonite.
Bauxite.
Psilomelane.
Calcite.
Dolomite.
Siderite.
Smithsonite.
Aragonite.
Cerussite.
Malachite.
Azurite.
Orthoclase.
Microcline.
Anorthoclase.
Albite.
Oligoclase.
Andesine.
Labradorite.
Anorthite.
Enstatite.
Hypersthene.
Augite.
Spodumene.
Wollastonite.
Rhodonite.
Hornblende.
Arfvedsonite.
Beryl.
Iolite.
Garnet.
Olivine.
Fayalite.
Idocrase.
Zircon.
Topaz.
Andalusite.
Sillimanite.
Kyanite.
Gadolinite.
Zoisite.
Epidote.
Axinite.
Calamine.
Tourmaline.
Staurolite.
Apophyllite.
Heulandite.
Epistilbite.
Phillipsite.
Harmotome.
Stilbite.
Laumonite.
Chabazite.
Gmelinite.
Levyne.
Analcime.
Natrolite.
Mesolite.
Thomsonite.
Muscovite.
Biotite.
Lepidomelane.
Serpentine.
Talc.
Glauconite.
Kaolinite.
Pyrophyllite.
Sphene.
Apatite.
Pyromorphite.
Vivianite.
Erythrite.
Wavellite.
Beudantite.
Barytes.
Anglesite.
Gypsum.
Amber.

VII.—The Canadian Rockies. Part I: On a Collection of Middle Cambrian Fossils obtained by Edward Whymper, Esq., F.R.G.S., from Mount Stephen, British Columbia.[1]

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

In the Summer of 1901 my friend Mr. Edward Whymper, the well-known traveller, mountain explorer, and writer, paid a visit to the watershed of the Canadian Rocky Mountains, and during a stay at Field, the highest pass reached on the Canadian and Pacific Railroad, he examined the slopes of Mount Stephen, and at a height of 6,000 feet on its northern side found numerous Trilobites, and brought home a considerable collection.

These fossils have been most obligingly placed in my hands by Mr. Whymper, and, although previously known, they have not all been adequately figured. I venture to think their illustration may be useful, accompanied by some further notes on the fossils associated with them.[2]

Locality.—Two mountain peaks, Mount Field (5,000 feet) on the right bank and Mount Stephen (8,000 feet) on the left bank of the Wapta or Kicking Horse River, stand as flanking bastions to the valley, whose base is about 4,500 feet above sea-level, and some miles to the east of which is the 'Great Divide,' the water-parting of the 'Rockies,' where the primitive sources of the mountain streams separate, the waters of the western side to join the Columbia River and the Fraser, and ultimately flowing to the Pacific, while those of the eastern side add their various contributions to the Bow River, which finally empties itself into Hudson's Bay.

The 'Rockies,' which run in a north-west and south-east direction, taken in their widest extent of lateral buttresses, may, speaking broadly, be said to embrace the Coast Range on the west, which is followed by the Gold Range, the Selkirks, *the Rocky Mountains proper*; then follow to the east the Foot Hills, giving place to the vast rolling Prairies beyond.

The earliest record of the discovery of fossils on Mount Stephen is that of Mr. L. M. Lambe, one of the Surveyors on the staff of the Canadian and Pacific Railway in 1884. (Mr. Lambe is now the Artist and one of the Assistant Palæontologists on the Geological Survey of Canada.) He obtained four specimens from this spot.

Mr. C. D. Walcott, describing "the Fauna of the Lower Cambrian, or *Olenellus* Zone," writes (p. 538):—"Geologists are indebted to the Geological Survey of Canada for the discovery of the *Olenellus*-zone in the Rocky Mountains of British Columbia. Dr. Geo. M. Dawson first obtained a species of *Olenellus*, like *O. gilberti*, at Kicking Horse Lake in British Columbia, and in 1887 Mr. R. G. McConnell described a section at Castle Mountain and Mount Stephen, which shows that the *Olenellus* fauna occurs at the base

[1] Read before the British Association for the Advancement of Science (Section C, Geology), Belfast, September 11th, 1902.

[2] After they have been examined by me Mr. Whymper will present them to the British Museum (Natural History).

of the Castle Mountain limestone, and that the Middle Cambrian fauna occurs 2,000 feet above." [1]

Subsequently Mr. Otto Klotz, whilst engaged on geodetic measurements in connection with the astronomical work of the Canadian Dominion, accidentally discovered the Trilobite bed on Mount Stephen, and presented the specimens he collected to the University of Michigan, his Alma Mater. The specimens afterwards were placed in the hands of Dr. C. Rominger, who described them in the Proceedings of the Academy of Natural Sciences, Philadelphia, 1887, pp. 12–19, pl. i. The descriptions are explicit, but the figures are not satisfactory, and I hope shortly to figure these Trilobites more fully. Meantime I am able to submit clear outline drawings of most of the species.

Dr. H. M. Ami, M.A., F.G.S., Assistant Palæontologist to the Geological Survey of Canada, Ottawa, who has visited Mount Stephen and geologized upon its slopes, kindly informs me that the beds containing the Trilobites represent about 300 feet in thickness. They form the summit of Mount Field, and rest at about 6,580 feet up on Mount Stephen; the summit of this latter mountain is composed of Palæozoic limestones, about 2,000 feet in thickness *above the black Trilobite shales*, the fauna of which has not yet been examined. Beneath the latter there are about 1,000 feet of calcareous and siliceous shales, while basal sandstones make up the residue.

	Section of Mount Stephen.	
1. At summit: Palæozoic limestones, fauna not yet examined	2,000 feet	Probably Upper Cambrian.
2. Black Trilobite shales	300 to 400 feet	Middle Cambrian fossils abundant (Walcott).
3. Limestones and shales, calcareous and siliceous shales	1,000 feet	Lower ? Cambrian series (no fossils).
4. Sandstones, basal sandstones ...	1,530 feet	

One feature of the scenery is that the mountains (as a whole) are nearly all carved vertically.

Mr. S. H. Reynolds, M.A., F.G.S., has brought back a series of the fossils from Mount Stephen (Field); these are now in the Woodwardian Museum, Cambridge, and a small, perhaps larval form has been described and figured by Mr. F. R. Cowper Reed, M.A., F.G.S. (in the Geol. Mag., 1899, Dec. IV, Vol. VI, pp. 358–361), and named ***Oryctocephalus Reynoldsi.***

Dr. G. F. Matthew, Mr. C. D. Walcott, and Dr. Rominger have all described fossils from this locality, and the Survey of Canada at Ottawa has a fine collection made by their own officers and also by Mr. Byron Walker, F.G.S., of Toronto. The following fossils have been met with at Mount Stephen, viz.:—

[1] "Report on the Geological Structure of a portion of the Rocky Mountains": Geol. and Nat. Hist. Surv. Canada, new series, vol. ii (1886–7), pp. 28–30d, with section.

TRILOBITA.

Neolenus serratus (*Ogygia serrata*).
Olenoides Nevadensis.
Olenoides, sp.
Ptycoparia Cordilleræ.
Ptycoparia, sp.
Bathyurus Dawsoni.
Bathyuriscus Howelli (*Embolimus rotundata*).
Ogygopsis Klotzi.
Ogygopsis, sp.
Zacanthoides spinosus.
Oryctocephalus Reynoldsi (Cowper Reed).
Agnostus interstrictus.
Agnostus, sp.

PHYLLOCARIDA.

Anomalocaris Canadensis (Whiteaves).

BRACHIOPODA.

Obolella, sp.
Acrotreta gemma.
Kutorgina pannula.
Lingulella ella.
Scenella, sp.
Hyolithes, sp.
Theca, sp.

Dr. Ami, in reply to my queries, says:—"I do not know of any greater elevation than that of Mount Stephen from which Trilobites have been obtained, *unless* the Pioche Nevada or the localities in Utah (where the same fauna also occurs) attain to a greater elevation. It would be interesting to compare the heights of Canadian with United States localities."

Certainly the Mount Stephen Trilobite beds are the *highest* point in the Rocky Mountains where Trilobites have been found.

It is a generally accepted axiom in geology that the oldest mountains in the world are now the least in point of altitude, having been subjected for such vast periods of geological time to subaerial denudation that we now only contemplate their degraded remains; the strata composing them being also, as a rule, highly metamorphosed and crumpled.

Here, however, we are presented with mountains composed of Cambrian strata—the oldest stratified rocks we know containing living organisms—having an elevation of some 6,000 feet above the pass, or 10,000 feet above sea-level, *rich in well-preserved Trilobites*, but little distorted, the strata lying in horizontal sequence, and in almost the same undisturbed condition as on the day, millions of years ago, when these deposits were laid down in the depths of the primordial ocean.

Mr. C. D. Walcott places the Trilobite shales of Mount Stephen in the *Middle* Cambrian series; but Dr. G. F. Matthew considers them to be *Upper* Cambrian in age. A careful examination of the 2,500 feet of basal shales, limestones, and sandstones upon which the Trilobite-bearing beds rest, is essential, as, if Dr. Matthew's contention is correct, they should represent the Middle and Lower Cambrian. Similarly, the 2,000 feet of overlying limestones, forming the summit of Mount Stephen, ought in that case to yield Silurian fossils to the enterprising climber who should scale their precipitous cliffs.

At least a dozen genera of fossils have rewarded Mr. Whymper's researches, and in a newly explored valley named 'Ball's Valley' (after the Alpine traveller, John Ball, F.R.S.), twenty-three miles distant from Field, Mr. Whymper discovered the same Trilobite- and Molluscan-bearing beds.

In addition to the Trilobites, etc., Mr. Whymper obtained good examples of *Anomalocaris Canadensis*, a remarkable phyllocarid Crustacean, described by Dr. J. F. Whiteaves, F.G.S., the Palæontologist to the Geological Survey of Canada.

Mount Field, which faces Mount Stephen, remains still unexplored, but is a part of the same *massif*, and will no doubt yield the same Cambrian fossils. It is only separated from its brother peak by the present pass, which glacial torrents working for long centuries have gradually widened into the existing river valley.

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

VIII.—The Exploration of Kesh Caves, County Sligo, Ireland.

By Dr. R. F. Scharff, B.Sc., F.Z.S., and others.[1]

Kesh, or as it is locally spelled 'Keash,' is fifteen miles south of the town of Sligo, and consists of a few scattered buildings, with farms about them. The spot is at the foot of Keishcorran Mountain, an isolated mass of Carboniferous Limestone which rises to 1,183 feet; and the country which extends south and west from this mountain for miles from Kesh presents an array of gravel eskers and elongated mounds of glacial material, with here and there a small lake or marsh in the hollows between them. Sprinklings of erratic boulders and stones occur up to the very summit of the mountain. These consist principally of red sandstone, with a few of yellow sandstone and of dyke rocks. It is believed that these rocks could be found in place on the next hill range to the south and south-east of Kesh, around Lough Key, but this point has not been definitely established. Though no continuous deposit of drift was seen on the mountain, these erratic blocks are sufficient to show that it has been overwhelmed by ice.

On approaching Keishcorran from Kesh one sees a grass-grown talus which extends up from the plain at a steep angle for several hundred feet. Surmounting this is a range of cliffs running along the mountain face like the gigantic walls of an ancient city. These are pierced along the top of the talus by a range of some thirteen caves. Towards the northern end of this series is a cavern whose large orifices, about fifteen feet high, can be seen for miles. The other caves are of various sizes, but the type which prevails is that of a vertical fissure enlarged downwards into an 'A' shape. The cliff which they penetrate faces S.W., or S.W. by W., and their direction is approximately parallel. These caves are intersected at various distances from their mouths by cross-fissures, which in

[1] Report of the Committee, consisting of Dr. R. F. Scharff (Chairman), Mr. R. Ll. Praeger (Secretary), Mr. G. Coffey, Professor G. A. J. Cole, Professor D. J. Cunningham, Mr. G. W. Lamplugh, Mr. A. McHenry, and Mr. R. J. Ussher, appointed to explore Irish Caves. Drawn up by the Chairman. Read before Section C (Geology), British Association, Belfast, September, 1902.

several cases form connecting galleries from cave to cave. This feature is more or less common to them all. The whole system of excavations, in fact, clearly depends upon the jointed structure of the limestone. The great cliff is due to the flaking away of the mass along one series of vertical joints, and solution works along the same series within, and produces passages and fissures parallel to the face. The caves connected by these fissures have also been worked out by solution, acting along the second vertical series of joints which run in perpendicularly to the great cliff face. The general slope of the cave floors is from within outwards, and the contained deposits are mainly the detritus and residue of the limestone rock, with fallen blocks from the walls and roof, set in a soft calcareous tufa.

Coffey Cave.—Our excavations were commenced in May, 1901, at the mouth of one of the larger caves, which is about central in the series, and which we distinguish as the Coffey Cave. It has a lofty A-shaped mouth, and a large deposit of clay occupies its lower portion. The section made in this across the cave's mouth disclosed the following deposits in descending order:—

1. *Surface soil* of a blackish brown, containing charcoal, a tine of Red Deer antler, the broken bones of domestic animals, and a few implements indicating temporary occupation by man rather than fixed settlement. The bones and implements are such as are commonly found in raths and crannogs, and the depth of this layer is from six to twelve inches.

2. *Breccia*, consisting of limestone blocks and fragments fallen from the roof, in a deposit of calcareous tufa. This bed contained numerous land-shells (*Helix*, *Hyalinia*, *Clausilia*) and bones of small mammals. Among these the Arctic Lemming was numerously represented as well as in the next stratum. This is the first instance in which this animal has been identified as a former inhabitant of Ireland. A mandible has been referred to the Irish Stoat, though smaller than that of a Weasel; and some canine remains have not yet been definitely identified. The depth of the breccia is from a foot in the centre increasing to three feet at the sides of the cave.

3. *Clay* of a brown ochreous colour containing large blocks of limestone and numerous bones of small mammals (including Lemming), as well as a few of larger ones. At a depth of six feet from the surface a large glaciated block of limestone was found.

Plunkett Cave.—Owing to the difficulty of removing the numerous limestone blocks we searched for more promising ground and decided to work at a smaller cave, one of the most southern of the series, which opened at a somewhat higher level. We called this the Plunkett Cave. A lofty entrance narrows down to a low mouth, from five to six feet wide, and inside this the cave becomes much more lofty and widens at a distance of from twelve to sixteen feet from the mouth. It then forms a gallery six to ten feet wide which pursues a generally straight course, terminating at forty-nine feet from the mouth. Before this termination is reached, however, a gallery branches off to the right, and this, after running some twenty feet, expands into a lofty hall, the Sloping Chamber, that has another branch to the left, parallel with the Plunkett Cave. We called this latter branch the Water Gallery.

At the commencement of the operations no part of these galleries was completely choked, but all contained a considerable depth of deposits, chiefly of earths and clays, with blocks and fragments of limestone.

The upper or surface stratum, which varied from six inches to two feet in depth, contained a large amount of calcareous tufa, and as we advanced into the inner galleries this tufa grew more and more free from earthy admixture, being in places as white as mortar. While a variable amount of calcium carbonate occurs in this deposit, its whiteness is in part due to the usual residue of siliceous particles that results from the removal of limestone in solution. Characteristic bipyramidal crystals of quartz are thus found in some parts; and in the Water Gallery a delicately spicular deposit occurs. A multitude of minute rods, sometimes set with knobs, are seen when the tufa is dissolved away in acetic acid. Dr. G. J. Hinde, F.R.S., who has kindly examined these for us, points out that they are crystalline and soluble in nitric acid. Their true character is still under consideration. In all parts of the cave explored by us this white stratum contained charcoal, sometimes in lumps and occasionally in horizontal layers, which formed distinct seams in our sections. In the most remote part excavated by us, the Water Gallery, there was a black layer of charcoal an inch deep, which extended from wall to wall, with a bed of white tufa above and beneath it, and at the bottom of the lower tufa there was more charcoal. Some pieces of peat were also found embedded elsewhere, which were probably brought into the cave for fuel.

In the lower part of the upper stratum a large stone celt was found five feet inside the cave's mouth, the only evidence of Neolithic occupation, and not far from it was a portion of a small iron saw of peculiar make, resembling those found in Dunshaughlin crannog, and in the same vicinity a bronze pin with a ring attached to it. The upper stratum contained a second bronze pin at thirty-eight feet from the mouth of the cave, and further in again was a small iron rod. Shells of marine Mussels repeatedly occurred in this upper stratum and also an oyster-shell, though the sea is now fifteen miles distant, and it is not likely to have been much nearer in Neolithic times.

The human remains were few, and occurred chiefly near the Sloping Chamber; but the bones and teeth of domestic animals were exceedingly numerous, and were found wherever the stratum extended. These were generally fragmentary and represented the species usually found in Irish kitchen middens, viz., horse, red deer, ox, sheep, goat, pig, and dog.

Among the wild species represented in this upper stratum fox and rabbit were numerous, hare and red deer less so; but an interesting find was a metatarsus of reindeer, which occurred in the gallery to the right, deep down in this stratum; while charcoal was found lower down in the same deposit and in the same bench, each bench measuring two feet wide.

In several parts of the cave the upper stratum contained bones of brown bear. These were found near the lower horizon of the deposit, so that in some cases they may have been lying on the surface of the clay which formed the second stratum where the deposition of the upper one commenced. In one case a bone of a bear was partly embedded in the upper stratum and partly in the clay.

Bones of field mice were numerous, as well as those of frog.

The second stratum of clay, which also extended throughout the galleries of the Plunkett Cave, was brown, inclining to ochreous, more or less sandy, and contained numerous fragments of limestone and chert. Worn rounded pebbles were scarce in the clay, and occurred chiefly in or near the Water Gallery.

The quartz sand in this yellowish clay seems to be truly detrital and of external origin; it sometimes largely predominates over the clayey particles. The clay itself, however, probably arises from the decay of certain layers of the limestone, since it contains, and at times abundantly, the typical bipyramidal crystals of quartz. Its non-calcareous nature shows that it was deposited when solution was fairly active, while the upper tufaceous deposits indicate conditions favourable to stalagmitic growth.

The presence of occasional worn pebbles of red sandstone in the interior of the caves might be explained on the supposition that the pebbles had been washed down pot-holes and crevices from the hill above. The gravelly deposit at the mouth of the Plunkett Cave could not, however, be thus explained. It is too thick and too limited in area, and some of its contained boulders are too large to have been thus introduced, and there seems no escape from the conclusion that the gravel has been washed to the mouth of the cave from without.

Some of the larger limestone boulders, especially those towards the top of the gravel, were undoubtedly glaciated (not only scratched, but exhibiting also the characteristic shape of glaciated blocks), and did not seem to have been worn or washed much since this glaciation.

There is not enough drift on the mountain above to explain the presence of the gravel as a down-wash, even if the contour of the hill were such as to render a down-wash of this kind possible, which is not the case. The plain of drift, with its characteristic original moundy topography, lies considerably below the mouths of the caves, with a steep talus slope now separating them, and it is highly improbable that there has ever been a plateau of drift material so high as the mouths of the caves at any time since the disappearance of the ice. There seems, therefore, to be no other explanation possible for the gravel deposit than that it has been washed into the mouth of the cave at a time when the ice was at least as high as the escarpment into which the caves are cut, and that the mouth of the Plunkett Cave was already an open passage at that period.

Hence it becomes a point of much importance to determine whether the caves contain any deposits of older date than the Glacial Period, and this point deserves especial prominence in any future exploration. The yellow clay with chert, the lowest deposit discovered, is not a true 'Boulder-clay.' It seems to be such material as might be derived from the solution of the limestone mixed with sand and mud from the waters entering the cave from without. We were not satisfied that this clay was older than the gravel deposit. No fossils having as yet been found in the yellow clay, the question as to its relation to the Glacial Period is at present of geological interest only, and no palæontological point is involved.

If a fossiliferous deposit were discovered below the yellow clay it would be of much scientific interest. That pre-glacially filled fissures may occur in the Carboniferous Limestones in this country is shown by the presence of an earth-filled fissure overlain by Boulder-clay in a limestone quarry at Howth, which one of us examined recently, but without noticing any fossils in it.

A block and cone of crystalline stalagmite were found in the clay in the Water Gallery, but these were the only examples noticed of this ancient form of stalagmite which had evidently been broken up in this cave.

The lower portion of the clay seemed to be devoid of bones as well as of any relics of man, but in the upper portion of this deposit we found animal remains, including a human tooth; and a little charcoal was met with in four different spots. This strongly contrasted with the abundance of the latter material, which was everywhere present in the upper stratum; and even these few traces of it must be mentioned with caution, as burrowing animals may have penetrated into the clay, and thus might have transmitted into it some bits of charcoal from the upper stratum. Remains of domestic animals, so abundant in the latter, were virtually absent from the clay, a bone or two of ox and of goat being all the relics in it assignable to those mammals. The pig was, however, represented in four places.

The characteristic animal throughout this stratum was the brown bear, whose bones and separated teeth numbered sixty at least, and occurred in all parts of the cave, becoming more frequent in the inner galleries. Fox was found in fourteen places, hare in seven, red deer in four, rabbit in three, wolf in at least one instance, and lemming once (at the entrance), while frog and field-mouse occurred repeatedly.

We sank deep sections in several parts of the cave, with the result that it was found to narrow downwards and was filled in that direction with barren clay, which became yellow and tenacious as the rock was approached in our excavations. Near the cave's mouth large quantities of yellow clay were found, and it may be proper to treat it as a separate deposit distinct from the brown sandy clay. No drift stones have been noticed in the yellow clay.

It will be seen from this report that during the deposition of the upper strata the Plunkett Cave was inhabited for a long time by men who used domestic animals and marine molluscs, and had implements of iron, bronze, and polished stone, and who, in the earlier part of this period, were contemporaneous with the reindeer and probably with the bear.

In the subjacent clay there are evidences, left during a previous epoch, that bears then inhabited the cave undisturbed by human intrusion.

TABULAR STATEMENT OF THE MAMMALIAN REMAINS (PRELIMINARY).

	Surface Stratum.	Breccia.	Clay.
Pig (*Sus scrofa*)	×	—	×
Horse (*Equus caballus*)	×	—	—
Ass (*E. asinus*)	×	—	—
Red Deer (*Cervus elaphus*)	×	—	×
Reindeer (*Rangifer tarandus*)	×	—	—
Sheep (*Ovis aries*)	×	—	—
Goat (*Capra hircus*)	×	—	?
Ox (*Bos taurus*)	×	—	?
Field-mouse (*Mus sylvaticus*)	×	×	×
Rat (*Mus decumanus*)	×	—	—
Arctic Lemming (*Dicrostonyx torquatus*) ...	?	×	×
Rabbit (*Lepus cuniculus*)	×	×	?
Hare (*Lepus timidus = variabilis*) ...	×	×	×
Bear (*Ursus arctos*)	×	—	×
Dog (*Canis familiaris*)	×	?	?
Wolf (*Canis lupus*)	×	—	?
Fox (*Vulpes alopex*)	×	—	×
Badger (*Meles taxus*)	×	—	—
Irish Stoat (*Putorius hibernicus*)	—	×	—
Man (*Homo sapiens*)	×	—	?

IX.—ON THE BROCKRAMS OF THE VALE OF EDEN, AND THE EVIDENCE THEY AFFORD OF AN INTER-PERMIAN MOVEMENT OF THE PENNINE FAULTS.[1]

By PERCY F. KENDALL, F.G.S.

THE author has been engaged during occasional visits to the Vale of Eden in the study of the well-known Brockram conglomerates which form so conspicuous an element in the Poikilitic series of the district. Tentative results obtained five or six years ago have been fully confirmed by later observations, and though the investigation is not quite complete, the author regards the present occasion as an opportune one for presenting a preliminary statement of views which have already obtained some currency by annual demonstrations in the field to scientific societies of the North of England.

The stratigraphical relations of the Brockrams can be well studied in the almost continuous sections which are exposed between Hoff Beck, two miles west of Appleby, and Brackenber Common, three

[1] Abstract of a paper read before the British Association, Belfast, September, 1902, in Section C (Geology).

miles east of the town. The beds dip to north-east at about 20 degrees, and the succession here exposed is as follows:—

St. Bees Sandstone (Trias).

PERMIAN.
6. Shales and Sandstones.
5. Hilton Plant Beds.
4. Magnesian Limestones.
3. Upper Brockram interbedded with and overlain by Penrith Sandstone.
2. Penrith Sandstone.
1. Lower Brockram.

Carboniferous rocks.

The Lower Brockram forms a bold escarpment near Hoff Beck, and the nature of its constituents can conveniently be studied in great clean faces of quarries as well as in natural exposures. In the course of a careful examination of the pebbles it has been found that all the pebbles, except some twenty or thirty at most, consist of Carboniferous limestone or chert, the former well rounded and frequently very fossiliferous—*Saccamina Carteri* was found in one. The stones ranged in size up to nearly a foot in diameter.

The few exceptions mentioned above were hæmatite, sandstone, and ten or twelve small pebbles of vein quartz such as might be found in the Millstone Grit, the Basement Carboniferous Conglomerate, or, more remotely, as veins in the Skiddaw Slates. Recurrences of the same bed, presenting the same characters as regards the nature and source of the pebbles, are seen on the west bank of the Eden below Appleby, on Gallows Hill, and at Hungriggs quarry, east of Appleby. At the last two localities the pebbles have been very extensively dolomitized subsequently to deposition, for the pebbles have in many cases been reduced to a mere shell, usually lined with crystals of calcite.

The same aspect of the Lower Brockram is presented in the exposures at Stenkreth (Kirkby Stephen) and to the northward of Hungriggs in several quarries. It can be seen from these facts that for a distance of ten or twelve miles along the strike, and for over two miles on the dip, the character of the pebbles in the Lower Brockram undergoes no change.

The Penrith Sandstone about Appleby attains to a thickness of probably a thousand feet, but no exact estimate is possible owing to the occurrence of a large number of faults, of unknown throw.

Near its upper boundary, numerous intercalations of the Upper Brockram Conglomerate occur, especially in the section in Hilton Beck.

The Upper Brockram in this section consists of a rather friable conglomerate, in beds of a foot or two in thickness, parted by beds of sandstone from a few inches up to 30 or 40 feet thick. The constituent pebbles are partly of Carboniferous Limestone, very soft and much dolomitized, but other elements frequently preponderate; these are well-rounded pebbles of vein quartz, angular pebbles and blocks of quartzite, fragments of conglomerate containing vein quartz in a quartzite matrix, and finally pebbles of rhyolite. At other exposures to the northward at Flakebridge the same characters recur.

The source of the different pebbles may now be considered. The limestones are of course from the lower part of the Carboniferous Series; they present peculiar features. The pebbles of vein quartz are clearly derived from the numerous quartz veins in the Skiddaw Slate of the Cross Fell inlier, but their thoroughly rounded condition shows that they must have come at an intermediate stage through some pre-Permian conglomerate. This conclusion is confirmed by the occurrence of fragments of conglomerate containing such pebbles, which is recognizable as the very characteristic Basement Carboniferous Conglomerate of the Cross Fell Range.

The angular blocks of quartzite can be matched precisely by the rocks which succeed the Basement Conglomerate of Roman Fell. The author at one time regarded the rhyolites as indisputable evidence of the exposure of the Borrowdale rocks of the Cross Fell inlier and denudation during Permian times, but while this still seems to be the most probable explanation of their presence in the Upper Brockram it is possible that they could have been derived from the Carboniferous Basement Conglomerate, in which at Swindale Beck a few such pebbles occur.

Setting aside the rhyolite pebbles, there is still a body of evidence which seems to warrant deductions of very great interest. The facts to be explained are the occurrence in the Lower Brockram of a practically pure gathering of Carboniferous Limestone, while the Upper Brockram contains a very high percentage of rocks from the very base of the Carboniferous Series. They might be explained on the supposition of derivation from opposite sides of the Vale of Eden, the Lower Brockram being supposed to come from the Carboniferous Limestone outcrop towards Orton, while the Upper Brockram was derived from the Pennine Range. This view has little to commend it. If the Carboniferous Basement Conglomerate were exposed to denudation during the deposition of the Upper Brockram, then the Carboniferous Limestone must have formed a bold escarpment at the same time; and that being granted, it is highly improbable that it failed to yield the materials of the Lower Brockram, which at Hungriggs is less than three miles from the outer Pennine fault which exposed a series of Carboniferous rocks in Permian times. Upon the alternative, and as it seems preferable, hypothesis, that the materials of the two Brockrams were all derived from the Pennine Chain, an inter-Permian movement of the faults which throw up the Cross Fell range and the well-known inlier seems necessary.

Professor Lapworth has pointed out that when an anticlinal fold is exposed to denudation the derivative beds will consist of the same material as those of the anticline, but in reverse order, the uppermost beds of the anticline will yield the pebbles of the lowest of the derivative beds, while the core of the anticline will be represented only in the highest of the derivative beds.

This principle may be illustrated by the Tertiary beds of the south-east of England; the Lower Eocene conglomerates contain only flint pebbles from the Chalk, while the high-level gravels which rest on the Bagshot series contain besides flint many pebbles derived from the Lower Greensand.

Where, however, the exposure is by a fault scarp the whole of the beds exposed in the scarp will contribute to the first-formed derivative conglomerates. The absence of detritus of the Basement Carboniferous from the Lower Brockram shows that the basement beds were not exposed in early Permian times, but a movement of the fault exceeding the thickness of the Penrith Sandstone brought the lowest members of the Carboniferous series above the surface at the time of the deposition of the Upper Brockram.

X.—On the Sequence of the Inferior Oolite Deposits at Bredon Hill, Worcestershire.

By L. Richardson, F.G.S.

The correct sequence of the Inferior Oolite deposits at this locality has always been a matter of uncertainty. This is due partly to the disturbed state of the oolite, partly to the scarcity of fossils. On Bredon Hill only the four lowest subdivisions of the Inferior Oolite series are preserved. In the Cotteswold Hills around Cheltenham they are, in descending order, the Lower Freestone, Pea-grit, Lower Limestone, and sandy beds characterized by a very distinctive ammonite, *Tmetoceras scissum*—the last being the sandy ferruginous limestones of Witchell. Professor Hull did not recognize the Pea-grit at Bredon, but stated that its most northern extension was at Notting Hill.[1] In 1863, however, Dr. Holl rectified this error, and remarked that its non-existence here was only true as regards its pisolitic structure.[2] Above Elmley Lodge that author noticed masses of limestone crowded with fragments of the spines and plates of Echinoderms, as well as numerous specimens of Bryozoa, and *Terebratula plicata*. Below the brow of the eastern extremity of the hill, above Ashton-under-Hill, Dr. Holl obtained *Rhynchonella cynocephala* in blocks of hard limestone, but was unable to find the bed *in sitû* or to offer any suggestion as to its probable stratigraphical position.

One mile north-west of Overbury Church is a large quarry, and although the strata here—as in the rest of the hill—are very much disturbed, it is possible to construct the sequence and also to obtain approximately the thickness of the several subdivisions. The sequence may be obtained by a study of the section afforded on the east side of the quarry.

The continuity of the sequence of the deposits is interrupted by a fault. On the north side about 12 feet of Lower Freestone is exposed, resting upon the equivalent of the Pea-grit. The top beds of this Pea-grit equivalent consist of hard yellowish limestones full of fragments of the spines and plates of Echinoderms. Capping the projecting mass of rock—separated from the east face of the quarry

[1] Mem. Geol. Surv.: "Geology of the Country around Cheltenham" (1857), p. 33. Notting Hill is locally known as Nottingham Hill.

[2] Quart. Journ. Geol. Soc., vol. xix (1863), p. 315.

by a small fault—similar yellowish limestone is seen, and passes downwards into a shelly development. *Terebratula simplex* (but only the pedicle valves) is abundant. The shelly rock is best exposed in the west side of the southern or disused portion of the quarry, and contains *Terebratula simplex, Ter. plicata, Rhynchonella subangulata, Rhyn. oolitica, Zeilleria circularis, Pygaster semisulcatus* ?, *Diastopora, Spiropora straminea*, etc., and ossicles of *Pentacrinus*. About 2 feet of hard yellowish-white oolitic limestone is visible below the Pea-grit, which latter attains a thickness of about 14 feet. On the south side of the fault the shelly strata of the Pea-grit are inclined at a high angle and rest upon a massive deposit of yellowish-white oolitic limestone, thickly bedded in its upper portion but becoming flaggy below. This Lower Limestone is about 34½ feet thick. The whitish flaggy development is seen capping the promontory on the opposite side of the quarry, and passes downwards into brown arenaceous strata, very ferruginous in places, and becoming more compact towards the base. This arenaceous rock—also containing fragments of sea-urchins abundantly—is exposed for a thickness of 13 feet. To the floor of the quarry is about 7 feet, and to the water-retaining stratum from this point, as proved in an old well, is about 8 feet. Thus, from the top of the arenaceous strata to the water-retaining bed is about 28 feet.

From evidence obtained in an old pit about 200 yards north-west of Kemerton Castle the thickness of this deposit, which contains a few *Rhynchonella cynocephala, Ter. euides*, and Belemnites, was estimated at 33 feet. In many quarries on the hill it may be noticed that the thickness of the Lower Freestone is very considerable.

Summarized, our knowledge of the Inferior Oolite at this locality is as follows:—

(1) Lower Freestone. Whitish oolitic freestone.

(2) Pea-grit equivalent. Compact yellowish limestone containing fragments of Echinoderms and a few of the characteristic Brachiopoda. 14 feet.

(3) Lower Limestone. Massive bedded yellowish-white oolitic limestone. 34½ feet.

(4) *Scissi* beds. Brown ferruginous, sandy strata containing *Ter. euides, Rhyn. cynocephala*, and a few Belemnites. 33 feet.

NOTICES OF MEMOIRS, ETC.

I.—Earthquake Investigations.[1] By Professor John Milne, F.R.S., F.G.S. (Reporter).

At the present time this Committee enjoys the co-operation of 38 similarly equipped observing stations, which are distributed in a fairly even manner over the different continents. All large earthquakes are recorded at each of these stations. At Professor Milne's station in the Isle of Wight the number of records obtained during the year is about 150. A map accompanying the Report shows

[1] Report of Committee read before Section A (Mathematical and Physical Science), British Association, Belfast Meeting, September, 1902.

the origins from which these world-shaking disturbances have originated. Nearly all of these, fortunately for humanity, are suboceanic and remote from thickly populated shores. From the sea-waves they sometimes create, the increase in oceanic depths found to have taken place after their occurrence, and the subsidences or upheavals of neighbouring shore-lines, the inference is that their cause is a caving in of some ill-supported portion of the earth's crust; a furrow on the face of the world has been deepened, whilst a bounding ridge may have been elevated. When these stupendous changes have taken place near to a volcano which has long been dormant, the violent shakings of its foundations have resulted in the imprisoned vapours suddenly bursting into activity. An activity of this description was apparently the immediate cause of the recent disasters in the West Indies; in fact, all the recorded eruptions in these islands have been preceded by sudden adjustments in neighbouring rocky folds.

Another section of the Report treats of the nature of the waves which so frequently pass through our earth and sweep its surface. Although this, like other sections, is of interest from a purely scientific standpoint, we observe that many of the investigations, as for example those bearing upon the choice of a site for an observatory, localizing districts where it would be unwise to lay a cable, have practical bearings of considerable importance.

With a desire to extend seismological investigations on the lines inaugurated by the British Association, we learn that the German Government had approached other nationalities inviting international co-operation. The Report before us indicates that co-operation of this nature is to a great extent *un fait accompli.*

II.—Note on the Occurrence of Bagshot Beds at Combe Pyne, near Lyme Regis.[1] By Horace B. Woodward, F.R.S.

In the Summary of Progress of the Geological Survey for 1900, p. 122, Mr. Clement Reid remarked, "It is probable that a chain of outliers of the Bagshot river-gravels will connect the Eocene of Dorset with that of Bovey Tracey in Devon."

The cuttings on the new railway between Axminster and Lyme Regis have since displayed, in the neighbourhood of Combe Pyne Hill, at an elevation of about 400 feet, beds of fine white sand, white pipeclay, and white, red, and mottled stony clays, with much rough flint and chert gravel. These beds have in places a marked inclination towards the east, due probably to original deposition, and in all respects they bear a close resemblance to the white and coloured clays and sands, and the coarse gravels, which border the Bovey basin at Wolborough and other places near Newton Abbot. They rest on a platform of Upper Greensand.

The beds at Wolborough I some years ago regarded as equivalent to the 'plateau drifts' of Haldon, but Mr. Reid has recently brought

[1] Abstract of a paper read at the British Association, Belfast, September, 1902, in Section C (Geology). Communicated by permission of the Director of the Geological Survey.

forward evidence to show that both are for the most part of Bagshot age, with the exception only of the deposits that have been rearranged in later times. There is, therefore, good reason for referring to the Bagshot series the beds at Combe Pyne, which are evidently *in sitû*, and which possess so many of the features characteristic of that formation.[1]

III.—THE GEOLOGY OF THE COUNTRY IN THE NEIGHBOURHOOD OF BELFAST.[2] By Professor GRENVILLE A. J. COLE, F.G.S.

BELFAST stands between the lava-plateaux of Cainozoic age in Antrim and the undulating surface of Silurian rocks in county Down. The special interest of the district lies in the preservation of Mesozoic rocks, which elsewhere are scarcely represented in Ireland. Schists and gneisses in the north-east of county Antrim possibly represent Archæan masses refolded during the Caledonian earth-movements. The Caledonian folds gave us the crumpled country of Down, and admitted the granite of Newry and Castlewellan along an axis running north-east and south-west. Both Ordovician and 'Upper Silurian' (or Gotlandian) strata are represented in this area. The conglomerate of Cushendun is probably of Old Red Sandstone age; but the Carboniferous Limestone, which is so marked a feature of Ireland as a whole, plays only a small part in the north-eastern counties. The Carboniferous strata of Ballycastle, west of Fair Head, are mainly sandstones with intercalated coal-seams, on the same horizon as the Calciferous Sandstone of the South of Scotland.

A patch of marine Permian strata occurs east of Belfast, at Holywood; and the British type of Trias, red rocks with salt and gypsum, is well represented under the basalt capping that has preserved it. The Rhætic sea spread into this area, and terminated far west against the Londonderry highlands; the Lias also began to form, and is now finely exposed at Waterloo, close to Larne. It is questionable if higher Jurassic beds than those now left to us were ever laid down in this region; elevation and denudation certainly set in early, and the country remained dry land until the middle of Cretaceous times. Then, in the westernmost extension of the great Chalk sea, the sands, conglomerates, and white limestone of Antrim were deposited, representing the Upper Cretaceous of England in a thickness of about 100 feet. The cliffs of hardened chalk, between red basement-beds of Trias and the black basalt scarp above, form, in Glenariff and Murlough Bay, one of the most beautiful contrasts in our Islands. It is clear that in early Eocene times both the counties of Antrim and Down were covered with a rolling series of Chalk uplands, resembling on a less massive scale our present Salisbury Plain. This quiet and newly upheaved country was destined to be devastated by volcanic action, more continuous and extensive than had been seen in the British Isles since Old Red Sandstone times.

[1] Particulars of the sections are given in the Summary of Progress of the Geological Survey for 1901, pp. 53–59.

[2] Read before the British Association, Belfast, Sept. 1902, in Section C (Geology).

The ground was first broken by rifts running from south-east to north-west, and these were quickly filled by basic lavas. Flow after flow emerged across the country, filling up the hollows carved by denudation, and forming in time continuous plateaux. Although a few explosive vents were established here and there, fluid basalt was the great feature of these eruptions. A time of quiet followed, when the lake-deposits and iron-ores of Glenarm, Ballypalady, etc., were accumulated; and sporadic outbreaks of rhyolite appeared, the most prominent being that of Tardree Mountain. Then the basic eruptions were renewed, and the columnar basalts of the Causeway coast belong to this second epoch of activity.

Mr. Starkie Gardner has referred these volcanic masses of Northern Ireland to early Eocene times, from a study of the plant-remains in the associated lake-deposits. Hence we find the marine Cretaceous beds followed by a terrestrial and igneous Eocene; and possibly some of the latest vents were active in Oligocene times. Thenceforward we know nothing of Irish geological history until the Glacial Epoch, which has left such piles of Boulder-clay and gravel across the country. The latest feature of interest is the blue marine clay of Belfast and Magheramorne, full of exquisitely preserved post-Pliocene fossils. This lies unconformably on the glacial drift, and represents a comparatively recent submergence and re-elevation. The raised beach of Larne, with flint-chips in it prepared by man, indicates the modern date of the movements of elevation.

When we go south from the immediate neighbourhood of Belfast, the Mourne Mountains rise conspicuously, their summits being far more bold than those of the adjacent Caledonian granite ridge. They are also formed of granite, which cuts across basic masses; the latter are seen at Carlingford to be at any rate post-Carboniferous. In turn, a few basic dykes of still later date traverse the granite. By its relation to these two basaltic series, and its petrographic identity with the Cainozoic granites of Mull and Skye, we need not hesitate to regard the Mourne granite as of Eocene age. It forms, then, as Mr. McHenry has pointed out, an interesting deep-seated mass for comparison with the rhyolitic lavas of the inter-basaltic epoch in county Antrim.

From the above notes, which have no claim to originality, it will perhaps be seen how attractive the Belfast area is to geologists, by reason of its very contrast with the accepted types of Jurassic, Cretaceous, and Cainozoic deposits, as known to us in the London Basin. Those familiar, on the other hand, with the geology of the Scottish Isles, will find many interesting points of similarity.

IV.—The Post-Glacial Deposits of the Belfast District.

By R. Lloyd Praeger.[1]

The silted-up head of Belfast Lough and other similar places in the district display a remarkably fine series of deposits extending from the close of the Glacial epoch to the present day, with a rich

[1] Abstract of a paper read before the British Association, Belfast, September, 1902, in Section C (Geology).

fauna, from which much of the history of the intervening period may be gleaned. A typical section at Belfast shows the following sequence:—

		ft.	in.
Surface clays	... ...	6	6
Yellow sand	... ...	2	0
Blue clay	Upper	6	0
	Lower	6	0
Grey sand	... ...	2	0
Peat	... ...	1	6
Grey sand	... ...	2	0
Red sand	... ...	4	0
Boulder-clay (base not reached)	... ...	15	0
		45	0

The peat bed, which at Belfast is twenty feet below low-water level, reappears between tides at various other places in the district. It represents an old land-surface, and its fossils include the 'Irish Elk.' The blue clay is the most important bed of the series. Two divisions can be clearly distinguished in it, the lower clay being littoral, and characterised by such shells as *Scrobicularia piperata*, the upper yielding an abundant fauna pertaining to five to ten fathoms of water. *Thracia convexa* is a characteristic fossil. In both clays some of the bivalves occur in beds, each shell in its natural position, and many of the species attain remarkably large proportions. In places the *Scrobicularia* clay is overlaid by raised beaches. Thus, at Larne, twenty feet of stratified gravels, containing marine shells and neolithic implements throughout, replace the *Thracia* clay, and serve to date it. The fauna of the *Thracia* clay has a distinctly southern aspect when compared with the present fauna.

As regards oscillations of level, the peat proves a level higher than the present in certain places by at least thirty feet. Subsidence, irregular both as regards rate and area affected, superseded to the extent of fifty to eighty feet; the final elevation, which brought about the existing state of things, amounted to thirty or forty feet.

As regards climate, the northern fauna of the Glacial period appears to have passed away by the time the peat was formed. Southern species immigrated till the molluscan fauna acquired a distinctly southern character in the upper blue clay; then the seas became again colder, and the present local molluscan fauna has a distinctly northern aspect.

V.—On the Marine Fauna of the Boulder-Clay.

By Joseph Wright, F.G.S.[1]

THE author has examined microscopically 112 samples of boulder-clay from various places in the British Isles and in Canada: 47 of these were from Ireland, 27 from England and Wales, 22 from Scotland, 1 from the Isle of Man, and 14 from Canada. In 71 of the British and in 9 of the Canadian samples foraminifera were found; the specimens of the clays had been taken from various

[1] Abstract of a paper read before the British Association, Belfast, September, 1902, in Section C (Geology).

altitudes, some few of them from localities over 1,000 feet above the sea. Almost all the forms found are referable to species which at present live at moderate depths off our coast, and most of them have the fresh appearance of these species. *Nonionina depressula* is often met with in great profusion, fully one half of the entire specimens found being referable to this species. One hundred and thirteen species have been found in the clays of Ireland, 72 in those of the Isle of Man, 65 in England and Wales, 40 in Scotland, and 15 in Canada.

In 31 of the gatherings no foraminifera were met with, whilst in some of the others they were very rare. The absence or the scarcity of specimens in some of the samples may be due, in part at least, to the circumstances that it was only the first floatings from the clays that were examined, and also that these minute organisms are liable at times to be overlooked when the material is being examined. To ascertain how far floatings could be relied on for giving conclusive results, 1 oz. troy of the boulder-clay from Woodburn, near Carrickfergus, was examined with the utmost care. The first floating was found to contain 1,400 specimens, the floating process being repeated 25 times before specimens ceased to come up; upwards of 600 additional specimens were thus obtained. What remained of the clay was then examined in detail with the microscope, and 67 more specimens were got from it.

In the boulder-clay at Knock Glen, near Belfast, 79 species were obtained, many of them being very rare forms, 6 being only known as recent British species from collections on the west coast of Ireland, 2 of these also occurring off the west coast of Scotland. The presence of these microzoa would lead us to infer that the clay at this place was probably deposited in deep water, when the land stood at a much lower level than at present, and when the marine conditions must have been somewhat similar to what now prevails off the west coast of Ireland.

VI.—The Fossil Flora of the Cumberland Coalfield.[1] By E. A. Newell Arber, M.A., F.G.S.

THE Cumberland Coalfield lies along the coastline to the west of the mountains of the Lake District. The towns of Whitehaven, Workington, and Maryport are three of the most important centres of the coal industry in Cumberland. In this district the Upper Carboniferous rocks consist of two series, of which the upper is the well-known 'Whitehaven Sandstone.' This is essentially an arenaceous deposit, and is often red or purple in colour. It is generally believed to lie unconformably on the 'Coal-measures' below, the latter consisting of argillaceous and carbonaceous material, and containing almost all the workable coals.

The horizons of both the 'Whitehaven Sandstone' and the 'Coal-measures' in the Carboniferous are disputed questions.

[1] Abstract of a paper read at the British Association, Belfast, September, 1902, in Section C (Geology).

Recently some attempt has been made to throw fresh light on the subject, from the evidence of the plant-remains which occur in both series, although not so abundantly as in some other coalfields. A full account of the floras, and the conclusions which have been attained, will, it is hoped, be published shortly elsewhere.

VII.—A Summary of the Principal Changes in South-East England during Pliocene and more Recent Times.[1] By Horace Woollaston Monckton, F.L.S., F.G.S.

(*a*) *Period of depression in South-East England.*

1. Deposition of the bed from which the Box Stones came.
2. The Lenham Beds. Sea 40 fathoms, extends to Guildford, shells not rolled, level 1,000 feet lower than now (Diestian).

(*b*) *Elevation in South-East England, but depression continues over estuary of Rhine.*

3. Gravel with large flints of Upper Hale, Aldershot, and the Pebble Gravel ('Westleton') of the Chilterns.
4. Coralline Crag, submarine banks in rather shallow water; climate that of South Europe.
5. Red Crag of Walton and Scaldisian of Belgium; sea-shore deposits, climate rather warmer than now.

The beds with *Corbula gibba* (Poederlian) complete Belgian series, and that country becomes dry land.

6. Red Crag of Bentley, Newbourn, Butley, sea-shore deposits. The Amstelian of Holland. Climate colder.

(*c*) *The depression of the estuary of the Rhine extends to South-East England.*

7. Norwich Crag deposited in sea-water of wide estuary. Chillesford Clay, shells not rolled or water-worn, level lower than now.
8. Weybourne Crag and Bure Valley Beds, depression extending and consequent introduction of *Tellina balthica*.

(*d*) *Period of great and extensive elevation.*

9. Cromer Forest Bed, level and climate as now.
10. *Leda myalis* Bed, marine with oyster-beds, shells in position of life. Slight local depression.
11. The Chobham Ridges Gravel and the Plateau Gravels around Reading over 300 feet O.D. come in here.
12. Arctic Fresh-water Bed, flood loam with *Succinea*.

The shells of Bridlington Shell Bed lived about this time.

13. The Cromer Till and Contorted Drift. First great ice-sheet. Lower Boulder-clay of many places, Bridlington Shell Bed, and Shell Bed of Moel Tryfaen, etc. Land higher than now.

(*e*) *Depression possibly only local in South-East England.*

14. The Middle Glacial Sand and Gravel, result from melting ice.

[1] Read before the British Association, Belfast, Sept. 1902, in Section C (Geology).

(f) Period of renewed great elevation possibly continuous with period (d) in the far north.

15. The Great Chalky Boulder-clay. Ice-sheet extending over large area.

N.B.—At some time during Periods (*d*), (*e*), (*f*), the land in North Europe was raised to some 8,000 feet higher than now, and this is probable date of completion of excavation of Scottish lochs and Norwegian fjords.

(g) Period of depression.

16. *Corbicula fluminalis* Beds of Grays and Crayford. Mammiliferous beds of Sewerby and Hessle. Slight depression.

Marine Gravel of Holderness 100 feet O.D., Brighton, Goodwood, etc., Raised Beaches. Further depression.

(h) Period of elevation over large area. Last great ice-sheet.

17. Plateau Gravel of Norfolk in part, and much of the Thames Terrace-gravel. Purple and Hessle Clay of Yorks.

Shell-banks of Rockall, etc., show elevation of Iceland, Scotland, Norway, to some 600 feet higher than now.

18. Mundesley 'River Bed' near close of this period.

Probably the Raised Beach of Clacton, etc., belongs to a final period of depression (time of Yoldia Clay of Christiania), and in Norway there was a subsequent elevation during which the terraces in the fjords were formed.

VIII.—A British and a Finland Meteorite.

It is of extreme interest to record that a meteorite fell near Crumlin, county Antrim, on Saturday, September 13th, at 10.30 a.m. Although the British Association was holding its meetings ten miles away, no one thought it worth while to investigate what appeared to be a hoax, and it remained for Mr. L. Fletcher to go over about a week later and secure the stone for himself. We quote Mr. Fletcher's own account of this fall, which appeared in the *Globe* newspaper:—

"As for the stone itself, it weighs 9 lb. $5\frac{1}{2}$ oz.; it is $7\frac{1}{2}$ inches long, $6\frac{1}{2}$ inches wide, and $3\frac{1}{2}$ inches thick. Its form is irregular and distinctly fragmental; there are nine or ten faces, each of them slightly concave or convex; the edges are rounded. Five of the faces are similar to each other in character, and except for minute pittings and projecting points, are smooth; they show those large concavities which are common on meteoric stones, and have been likened in shape to 'thumb-marks'; the remaining faces are different in aspect, and have a low ridge-and-furrow development; they are doubtless due to fractures during the passage of the stone through the earth's atmosphere, possibly to the break-up at the moment of detonation. A crack going nearly half-way through the meteorite at a distance of an inch from an outer face was probably caused by impact on the larger stone met with in the soil. The meteorite is virtually completely covered with the characteristic crust which is formed during the passage of such bodies through the air; the crust is in parts black, in parts brown, perhaps owing to the influence of the soil. On the smoother faces already referred to, the crust is thicker than, and different in aspect from, that on the remaining faces. From this it is inferred that the meteorite broke up in the earth's atmosphere at an early part of its course, when the speed was still so enormous that the heat produced by compression of the air in front of the quickly moving stone was sufficient to scorch the newly broken surface, for a fresh fracture of the stone is quite light in colour. In one part the crust is iridescent in purple, blue, and pink colours. Here and there bright particles of a metallic alloy of iron and nickel interrupt the continuity of the dark crust. On one of the smaller surfaces of latest fracture there is visible a section of a large flat nodule of the bronze-coloured protosulphide of iron, troilite, which is a characteristic mineral constituent of meteorites, and is not found as a native terrestrial product. Owing to the presence of particles of nickel-iron dispersed through the stony matter, the meteorite affects the magnetic needle, though not to a great extent. A mould of the meteorite has been made from which models will be prepared; a detailed mineralogical and chemical examination of the material of the stone will be at once begun."

The Bjurböle Meteorite.—Wilhelm Ramsay and L. Borgström contribute to the Bulletin de la Commission géologique de Finlande (No. 12, 1902) a full account of this fall, which occurred on the 12th March, 1899. It smashed through the ice which covered the fjord, and bedded itself in the mud to the depth of six metres. The ice at the point was 40 cm. thick, and fortunately there was only 90 cm. of water, so its recovery was not difficult. It was recovered in several pieces, the total weight of the lot being 328 kilograms. Its chemical composition seems to be of especial interest, but we have not room for further detail, and must refer the reader to the original paper. Bjurböle is about 50 kilometres N.E. of Helsingfors.

IX.—Short Notices.

1. Pliocene Voles.—Dr. Forsyth Major has studied the Voles from the Upper Val d'Arno and the Norwich Crag, and his results are embodied in a valuable note in the Proceedings of the Zoological Society of London, just issued. According to Dr. Major, Mr. Newton's *Microtus intermedius* forms a well-defined group of these animals, not a species, and is raised to the rank of a genus, *Mimomys*. Three species are defined altogether, but the author wisely says, "I am, however, quite convinced that at least double this number of species ought to be recognised, and am only prevented from doing so at present because I do not wish to found species on isolated teeth," remarks which might well be taken to heart by describers of scraps and fragments of bone and other imperfect and indeterminable material.

2. Carboniferous Arachnids. — When studying the Arachnida from the Permian of Bohemia for my work "Fauna der Gaskohle" (says Professor Dr. Anton Fritsch), I came to the conclusion that no

definite judgement was possible, before the Arachnida figured and described by Corda and Kusta from the Bohemian Carboniferous had been re-examined. Towards the conclusion of the work mentioned above, I took this in hand and prepared a work with many plates and restorations, which work will perhaps appear before the end of the year. I came to the following results, which are here noted since they interest a wide circle.

Cyclophthalmus senior, Corda, has no circle from the lateral to the large middle eyes, but there are merely angular granules on the median keel, as one sees in recent Buthidæ.

The restored figures of the eyes of *Cyclophthalmus*, which Corda gives on p. 37, as well as those of recent *Androctonus*, are fanciful and have no basis in fact.

Such position of the eyes as Corda figures for *Androctonus* exist in no known scorpion, and must have arisen from his mistaking the granules of the median keel for eyes.

Cyclophthalmus has merely two large median eyes, and, anteriorly on each edge, three lateral eyes, as in the recent *Buthus*. I have observed the latter in two species.

The Anthracomarta belong to the Trogulidæ, and it was necessary to settle which of the portions represented in the impressions belongs to the upper and which to the under sides. *Eophrynus* comes near to *Trogulus*, and has nothing to do with *Phrynus*.

The various genera of spiders which Kusta has described belong to the Arthrolycosidæ, which are the forerunners of the Mygalidæ.

The spider from Nyran (*Promygale*) shows by the possession of marginal plates a connecting link between the Trogulidæ and the Arthrolycosidæ.—*A. Fritsch*, Zool. Anzeiger, xxv, 16 June, 1902.

3. First Steps in Photo-micrography. By F. Martin Duncan, F.R.H.S. (the Amateur Photographer's Library, No. 25). Crown 8vo; pp. 104, with 16 text figures. (London: Hazell, Watson, & Viney, Ltd., 1902. Price 1*s*. nett.)

In this little work the author describes the methods and apparatus for use in low- and high-power photo-micrography; also development, printing, and lantern-slide making. The work is manifestly the result of the author's own practical experience, aud will be of great service to geologists who desire to produce their own photographs and to make lantern-slides of minute objects.

4. *Acrothyra* and *Hyolithes*: a Comparison. By G. F. Matthew, D.Sc. Trans. Roy. Soc. Canada, ser. ii, vol. vii, sec. iv, p. 93.

Having described a new genus of Brachiopods from the Basal Cambrian rocks of Cape Breton, Dr. Matthew proceeds to compare it with the genus *Hyolithes*, in which he finds analogous conditions of growth and musculation. *Acrothyra*, the new Brachiopod, is very like in form to the obtuse tubes of certain *Hyolithes*, and appears to have lived under somewhat similar conditions.

A close comparison of the muscular systems in these two forms shows some points of resemblance, and others of radical difference; the two forms, therefore, are not supposed to be very closely related, but to be independent types, separately developed from the Worms.

5. *Hyolithes gracilis* and Related Forms from the Lower Cambrian of the St. John Group. By G. F. Matthew, LL.D. Trans. Roy. Soc. Canada, ser. ii, vol. vii, sec. iv, p. 109.

A very slender form of *Hyolithes*, a variety of *H. gracilis* of the *Paradoxides Œlandicus* (cf. *P. Tessini*) zone, from a somewhat lower horizon, is described in this paper. The form resembles *Orthotheca Hermelini*, Holm, from the base of the Cambrian in Sweden, but has a more projecting dorsal lip. Figures are given to show the forms of this species found in the St. John Group. The shell has several chambers in the apex, and so is of the subgenus *Camerotheca*. The operculum was not found.

REVIEWS.

Memoirs of the Geological Survey of England and Wales. (London, E. Stanford, and of all booksellers.)

1. The Geology of the Country around Southampton (Explanation of Sheet 315).[1] By Clement Reid, F.R.S.; with contributions by W. Whitaker, F.R.S. 8vo; pp. 70, with illustrations of Chalk and London Clay fossils, also Palæolithic implements and geological sections. (1902. Price 1*s.* 6*d.*)

THIS area comprises a part of the Hampshire Basin formed of Chalk and Tertiary strata, and modified by some minor undulations in the strata. Thus the Portsdown anticline, which occurs to the east, has been shown to affect the area from the occurrence of several new inliers of London Clay (pp. 10 and 41).

Special attention is directed to the fossils of the London Clay and Bracklesham Beds; and to the flint implements of the plateau and valley deposits, which are illustrated. So many and varied fossils occur in the Bracklesham Beds of the New Forest at Brook, Bramshaw, Huntingbridge, and Southampton, as shown by the lists given pp. 27–34 and p. 40, that a more liberal number and better quality of illustrations might well be expected. Indeed, the area is so extremely prolific in fossil remains that it deserves and will no doubt obtain a more extended memoir at no distant date.

Records are given by Mr. Whitaker of numerous well-sections.

2. The Geology of the Country around Exeter (Explanation of Sheet 25). By W. A. E. Ussher, F.G.S.; with Notes on the Petrology of the Igneous Rocks by J. J. H. Teall, M.A., F.R.S. 8vo; pp. 122, with 20 Illustrations in the text. (1902. Price 2*s.*)

IN this work there is an account of the unproductive Culm-measures, and full particulars of the subdivisions of the New Red Sandstone series which occupy a large portion of the country around Exeter.

Much interest attaches to the volcanic rocks which occur in the lower part of the New Red Sandstone, and a petrological description of these is contributed by the Director of the Geological Survey. There are notes also on the superficial deposits, water-supply, etc.

[1] This memoir has already been referred to in the Geological Magazine for October, p. 478.

A long interval may well have elapsed between the resurvey of the area and the publication of this Explanation, for we do not find any reference to the wonderful discovery by Dr. G. J. Hinde and Mr. Howard Fox[1] of Radiolarian rocks in the Lower Culm-measures, which embrace a large extent of the Exeter area, dealt with in this Memoir, although the paper was read before the Geological Society in June, 1895.

Palæontological evidence has been of late shown to be as important as ever to the stratigraphical geologist, and no 'Royal Hammerer' can afford to neglect it if he values his reputation for 'up-to-dateness.'

3. The Geology of the Country around Ringwood (Explanation of Sheet 314). By Clement Reid, F.R.S.; with contributions by F. J. Bennett, F.G.S., and E. E. L. Dixon, B.Sc., F.G.S. 8vo; pp. 62, with 4 Illustrations in text. (1902. Price 1*s.* Price of Sheet 314 and a colour-printed map of the Ringwood district, 1*s.* 6*d.*)

IT would be an excellent plan if with every Memoir published by the Survey the colour-printed map or sheet belonging to the Explanation were (as in this instance) found folded up inside the cover. It would add enormously to its worth.

A description is given in this Memoir of the north-west portion of the Hampshire Basin, including the fine range of Chalk hills bordering Cranborne Chase on the north-west, and a part of the picturesque woodland of the New Forest, formed of Tertiary strata, on the south-east.

Attention is called to the evidence of an old river-course, which, probably in Newer Pliocene times, connected the Salisbury rivers with Southampton. On p. 34 is given an explanation aided by a very useful diagram of the River Valley Terraces of the Avon, from 100 to 400 feet above sea-level, which Mr. Clement Reid divides into—(*a*) Pliocene (high plateau), 400 feet; (*b*) Early Glacial; (*c*) Eolithic (second terrace); (*d*) Palæolithic (first terrace); (*e*) Late Glacial (valley gravel); (*f*) Alluvium (100 feet), down to the present river channel.

Well-sections are given in an Appendix.

The map, which has been executed at the Ordnance Survey Office, is clearly and well printed on a scale of one inch to the mile; the names and boundaries are very legible and distinct, and the colours pleasing to the eye. The Geological Survey is certainly to be congratulated on the introduction of colour-printed one-inch maps.

4. Summary of Progress of the Geological Survey of the United Kingdom and of the Museum of Practical Geology for 1901. 8vo; pp. 220, with 7 Illustrations. (London, 1902. Price 1*s.*)

SAVE in the margin, there is no author's name to this work. The whole represents the Director's Report for the year 1901, and should have borne his name on the title-page, as the responsibility for it rests upon his shoulders.

[1] See Quart. Journ. Geol. Soc., vol. li (1895), pp. 609–668, pls. xxiii–xxviii.

The Summary contains a rather full account of the field-work of the Geological Survey in England and Wales, Scotland and Ireland, and of the chemical, petrological, and palæontological work in connection therewith, also the work of the Museums in London and Edinburgh.

Progress has been made in Cornwall and Devon in subdividing the great Killas formation, and even the Granite of the Land's End area has proved susceptible of critical subdivision. In the South Wales area the detailed examination of the Coalfield has proceeded as far west as Swansea, and some new inliers of Silurian rocks have been detected in Gower. The resurvey of the Midland Coalfields has been continued.

In Scotland further particulars have been obtained with regard to the Highland Schists and the various Granite masses. Cretaceous rocks have for the first time been noticed in Soay Sound and Scalpay.

In Ireland the Drifts have been surveyed in the Dublin area.

Analyses of South Wales Coals have been commenced, and some notes on weathering of Magnesian Limestone are published.

A list is given on pp. 94, 95 of various maps, sections, and memoirs issued during 1901 for England and Wales, e.g., Sheets 261 and 262 (Bridgend), in one map. Index Map, Sheets 8 and 11 have been revised, and Sheet 12 reprinted. Forty-nine manuscript coloured copies of 6 inch sheets and quarter-sheets have been deposited in the Office at Jermyn Street for public reference. Three sheets of vertical sections have been published. A list of memoirs and extra-official publications is added.

Details of the palæontological work performed in the Museum and Survey Office for Scotland in Edinburgh are given on pp. 177 to 182. Two sheets of the 1 inch map have been published—one of Arran, part of Bute, and the Cumbraes, the other of Loch Lomond, Loch Katrine, and Callander. A list is also given of extra-official publications for the year.

For Ireland thirteen 1 inch maps have been revised and issued at the Dublin Office. These maps relate almost entirely to the Ordovician and Silurian rocks of Ireland, and should prove of much interest to geologists. In Appendices A and B Mr. H. A. Allen furnishes lists of figured and type specimens of British fossil Phyllocarida and British Palæozoic Echinodermata preserved in the Museum of Practical Geology, London. We hope soon to see the whole of the types and figured specimens belonging to the Survey published separately; they will be of the greatest value to workers in palæontology.

We congratulate Mr. J. J. H. Teall, the Director of the Geological Survey, on the excellent work of 1901, and look forward to even greater results in 1902.

The Board of Agriculture desire to give notice that copies of all the Memoirs and Maps of the Geological Survey may be obtained from any agent for the sale of the Ordnance Survey maps, or through any bookseller from the Ordnance Survey Office, Southampton.

CORRESPONDENCE.

OFFASTER PILULA.

Sir,—Mr. Sherborn is right as to the unfortunate slip in the recently published Memoir on the Geology of Southampton. Having Dr. Barrois' book open before me when I wrote the paragraph, I seem to have forgotten for the moment the more recent authorities. Elsewhere I have correctly referred the highest Chalk in that neighbourhood to the zone of *Actinocamax quadratus*.

Clement Reid.

October 8th, 1902.

LAKES OF SNOWDONIA.

Sir,—In my letter which appeared in the September number of your Magazine (p. 430, line 16 from top of letter) is an erratum which destroys the significance of the sentence. For 'sunny' read 'snowy.'

J. E. Marr.

Cambridge, *October 9th*, 1902.

RIVER DEVELOPMENT.

Sir,—Because I frankly admitted that statements in my paper in *Natural Science*, vol. xiv, 1899, might be termed "mere speculation," giving as the reason that the maps which we can obtain do not supply sufficient information for the precise study required, Mr. Strahan thinks he was justified in characterizing my work as "transgressing the limits of legitimate speculation." Yet he had just admitted not having seen the paper in *Natural Science* when he made that remark.

There is all the difference between my admission and Mr. Strahan's remark. Any theory is a speculation. I gave the grounds on which the theory was based; and I followed out the logical conclusions. The basis of the theory is that the original rivers flowed with the dip. As the general dip of the area in question is from north-west to south-east, that involves an original river-system such as was depicted in my map. Strong evidence in favour of the theory is found in the peculiar course of the tributaries on the left bank of the Severn, and in the breaches of the Cotteswold escarpment.

It is difficult to admit that in a country of simple structure such as the Cotteswolds, a Chalk anticline and all that it involves could be masked.

As to the indefinite westerly rise of the Chalk, is it so very great? The rise of the Oolitic surface on which the Chalk could have rested is about 800 feet in 25 miles. Having regard to the thickness of the Chalk and the extent of its outcrop, can its rise be much more than this?

One word about the Moreton anticline. I described *an* anticline there, formed and covered over again in Inferior Oolite time. We need not suppose this was *the only* anticline. On the principle of "successive movements along the same line of weakness," there were probably several successive upheavals along the line of the Moreton Valley. One such upheaval may have been post-Cretaceous, only the axis of such anticlines runs north and south.

S. S. Buckman.

MISCELLANEOUS.

Retirement of Mr. Frederick William Rudler, F.G.S.

To those at all well acquainted with the geological, mineralogical, and mining worlds of London, no name or presence is more familiar at meetings of scientific men, or as a lecturer and speaker, than that of Mr. F. W. Rudler, the eminent Curator of the Museum of Practical Geology at the Geological Survey in Jermyn Street, S.W.

Mr. F. W. Rudler (who retired September 30th) has filled the post of Curator and Librarian to the Museum of Practical Geology since the death of Mr. Trenham Reeks in 1879. Prior to this Mr. Rudler was for three years Professor of Natural Science in the newly-formed University College at Aberystwith, a post which he relinquished at the urgent request of the late Sir A. C. Ramsay, in order to take up the Curatorship of the Jermyn Street Museum. In earlier years, from 1860 to 1876, Mr. Rudler was Assistant Curator, and during this period he prepared new editions of the Descriptive Guide to the Museum, and also of the Catalogue of Pottery and Porcelain, works which are full of expert knowledge.

As a lecturer and public speaker Mr. Rudler is widely appreciated on account of his clear and admirable exposition of whatever scientific subject he undertakes to discourse upon, and we trust that in this respect his career may long continue. As a referee on all matters within his wide domain, he has been unequalled. Like Monsieur Houdin's wonderful bottle, no matter upon what particular subject one may require his assistance, his sources of knowledge have proved both varied and unfailing and have only been equalled by the readiness, the excessive kindness and amiability with which he at once has imparted his knowledge to all. As Treasurer of the International Geological Congress (London) in 1888, his energy, ability, and tact contributed largely to render that meeting memorable. Mr. Rudler has been for long a writer for the *Athenæum* and other journals, and is one of the best-informed men on all branches of scientific literature, while having a special knowledge of mineralogy, anthropology, and ceramic art. His absence from his accustomed study in the Museum at Jermyn Street will long be keenly felt by those who have been privileged to know and consult him. He will be succeeded by Mr. J. Allen Howe, B.Sc., whose training at the Royal College of Science and subsequent work on the Geological Survey well qualify him for the arduous post to which he has been appointed.

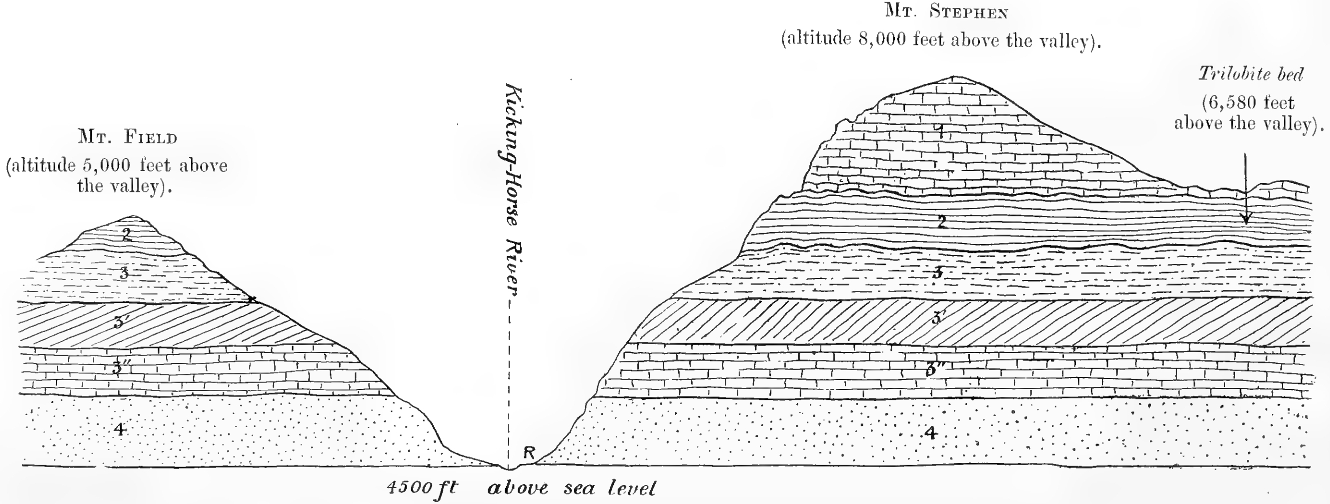


DIAGRAM-SECTION OF MT. STEPHEN AND MT. FIELD, Canadian Rocky Mountains, B.C., divided by the Wapta or Kicking Horse River. *R*, site of Field Station, Canadian and Pacific Railway; 1, Palæozoic limestones (not yet examined), probably Upper Cambrian; 2, black Trilobite shales, 300 feet thick, Middle Cambrian; 3, 3′, 3″, 4, limestones, shales, and sandstones, Lower Cambrian Series (no fossils have yet been detected in these beds).

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. IX.

No. XII.—DECEMBER, 1902.

ORIGINAL ARTICLES.

I.—The Canadian Rockies. Part I: On a Collection of Middle Cambrian Fossils obtained by Edward Whymper, Esq., F.R.G.S., from Mount Stephen, British Columbia.[1]

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

(PLATE XXII.)

(*Continued from the November Number, p.* 505.)

THE accompanying section (Plate XXII) will serve to show, *diagrammatically* (after Dr. Ami), the succession of the Cambrian rocks at Mount Stephen and Mount Field, B.C., and the position of the Trilobite bed on the flanks of Mount Stephen (referred to on p. 503) from which Mr. Whymper's collection was obtained.

Mr. C. D. Walcott, in his paper on the Cambrian fauna of Mount Stephen (Amer. Journ. Sci. [3], 1888, vol. xxxvi, pp. 161*–166), writes: "Of the nine or more species found at Mount Stephen, six are stratigraphically located in the Cambrian system. Two species—*Ogygia* ?? *Klotzi* and *Ptychoparia Cordilleræ*—are unknown from any other locality.

"The next fauna above the *Olenoides* beds of the Highland section is of Upper Cambrian or Potsdam age, and contains three undetermined species of *Hyolithes*; *Dicellocephalus Pepinensis, D.* (type of *D. Minnesotensis*), *Dicellocephalus* sp.; *Ptychoparia* (*Euloma* ?) *dissimilis, Ptychoparia* sp. ?; *Arethusina Americana*; *Illænurus* sp. ? Of this fauna two species are identical with those from the higher Potsdam fauna at Eureka, viz. *Ptychoparia* (*E.* ?) *dissimilis* and *Arethusina* ? *Americana*; whilst *Belleroparia antiquata* and *Dicellocephalus Pepinensis* occur in the Upper Potsdam sandstone of Wisconsin. The presence of the *Pleurotomaria*-like shells and the species just mentioned correlates the fauna of Mount Stephen with that of the upper horizon of the Potsdam faunas of Wisconsin and Nevada.

[1] Read before the British Association for the Advancement of Science (Section C, Geology), Belfast, September 11th, 1902.

"From the data mentioned I am led to conclude that the Mount Stephen fauna described by Dr. Rominger should be referred to about the horizon of the upper portion of the Middle Cambrian fauna. This correlation, united with the discovery of the *Olenellus*-fauna by Dr. George M. Dawson, in 1885, near Kicking-Horse-Pass, on the line of the Canadian Pacific Railway, leads me to think that the Middle Cambrian fauna will be found to extend all along the western side of the great Keweenawan continental area, from Southern Nevada far into British America, and that this area will be found to belong to one geologic and faunal province of the Cambrian system.

"Dr. Rominger describes the new genus *Embolimus* and five new species of Trilobites, viz., *Ogygia Klotzi, O. serrata, Embolimus spinosa, E. rotundata,* and *Conocephalites Cordilleræ.* He also identifies *Monocephalus Salteri* ? Billings, *Bathyurus* ? *Agnostus* (compare *A. integer,* Barr.), and the genera *Orthis, Obolella, Kutorgina, Leptæna* ? *Metoptoma,* and *Hyolithes.*"

Ogygopsis Klotzi, Rom., sp., 1887.

Ogygia Klotzi, Rominger, 1887: Proc. Acad. Nat. Sci. Philad., p. 12, pl. i, fig. 1.
Ogygia Klotzi, Walcott, 1888: Amer. Journ. Sci. [3], vol. xxxvi, p. 166.
Ogygopsis Klotzi, Walcott, 1888: Proc. U.S. Nat. Mus., vol. xi, p. 446.
Ogygia [*Ogygopsis*] *Klotzi,* Roem., G. F. Matthew, 1899: Proc. & Trans. Roy. Soc. Canada [2], vol. v, p. 58.

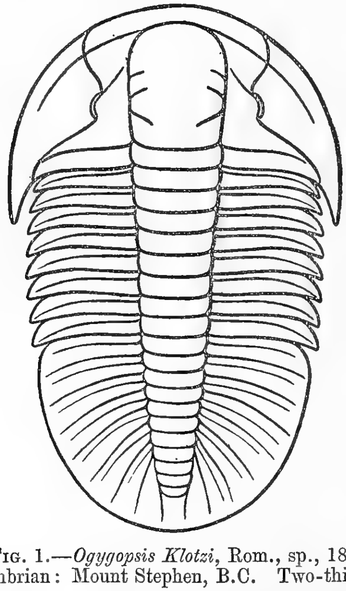


Fig. 1.—*Ogygopsis Klotzi,* Rom., sp., 1887.
Middle Cambrian: Mount Stephen, B.C. Two-thirds nat. size.

This Trilobite is one of the most abundant of the species obtained from the Middle Cambrian of Mount Stephen, B.C. In Mr. Whymper's collection there are twenty-eight nearly complete examples and twelve pygidia. There are also fourteen examples of *O. Klotzi*, junior, showing the younger stages of this well-preserved species.

Rominger states that this species attains a length of 11 centimetres and a breadth of 6 centimetres, and that specimens graduate down to as small as 16 millimetres in length. Of the fine series brought home by Mr. Whymper, only two or three examples have the free cheeks attached to the head. This suture-line, separating the free cheek from the fixed cheek and glabella, was evidently a weak line of union in the hard head-shield of most Trilobites, save in forms like *Illænus, Homalonotus*, etc., in which it is generally more firmly united to the head.

One is at first struck by the remarkable family likeness between *O. Klotzi* and *O. Buchi* from our own Llandeilo Flags, but after a more careful comparison one observes many important points by which to distinguish them from one another. In *O. Klotzi* the difference between the length and breadth is as 11 cm. to 6 cm., whilst in *O. Buchi* the length is $12\frac{1}{2}$ cm. to $10\frac{1}{2}$ cm. in breadth. Both the Mount Stephen and the Builth specimens, as is usually the case with fossils preserved in a slate rock, have undergone considerable compression.

The comparative length of the head, thorax, and pygidium is 3, 3, and 4 cm. respectively, the tail being the longest division of the body. The axis of the body, which is 18 mm. wide at the neck-furrow, diminishes very gradually to 10 mm. and less near the distal extremity, but is not visibly constricted as in *O. Buchi*, in which the axis rapidly diminishes from 15 to 5 mm. in the pygidium (see Salter's figures).

The glabella is nearly straight-sided and not expanded in front, as is usually the case in *Ogygia* proper. There are three lateral furrows in the glabella, which is rounded in front and separated from the anterior border by a fairly broad rim. There is a well-defined ocular ridge, and the palpebral lobe is narrow. The neck-furrow is smooth, and about 4 mm. deep by 18 mm. broad.

The fixed cheeks are narrowest at the orbits and expand broadly in front of the eyes, with a compressed semicircular outline around the glabella, and are half as wide as the glabella itself, only contracting slightly before uniting with the latero-anterior margin. Behind the orbits the fixed cheeks again expand outwardly at an acute angle, until they reach the ends of the neck-segment. The free cheeks are axe-shaped (the outer cheek border representing the rounded cutting-edge of the axe-blade). The latero-posterior angle of the crescent-like free cheek is produced backwards as a short stout spine which reaches to the third free thoracic segment.

Thoracic segments eight in number, but little curved, axial portion without ornament of ridges or tubercles, pleural portion about one-third longer than width of axis; pleural groove distinct, pleuræ slightly curved and pointed at their extremities, and very uniform in size; pygidium deep, but less broad than in *O. Buchi*; ribs of tail reaching nearly to the border, with no very distinct smooth or striated margin as in *O. Buchi*, only a narrow convex rim against which the coalesced pleuræ abut. There are about eleven well-marked coalesced segments in the pygidium, and their backward curvature is much greater than that of the free thoracic segments, gradually increasing more and more towards the extremity of the tail, where they meet the axis at a very acute angle indeed.

When comparing *O. Klotzi* with our English forms of *Ogygia* one is led to the conclusion that the earlier forms such as *O. Selwyni*, Salter, and *O. peltata*, are probably nearer the species from Mount Stephen than is *O. Buchi*; but that is not the opinion of Mr. Walcott. In any case *O. Klotzi* must be considered as a remarkably specialized form, to be met with in such early rocks as the Middle Cambrian of Mount Stephen, and has led Dr. G. F. Matthew to suggest that this bed may be really of Upper Cambrian age.

Walcott says of this Trilobite: "This is a fine large species, and distinct from any known to me from the Cambrian terrane. It is more a type of the second fauna than of the first; and its reference to the genus *Ogygia* is in accord with its general characters. It differs, however, in the important feature of having an ocular ridge extending from the anterior margin of the eye to the dorsal furrow beside the glabella. The palpebral lobe is also more narrow and elongate than the eye of most species referred to *Ogygia*. All other parts of the head, thorax, and pygidium relate it more closely to *Ogygia* than to any other genus. The oldest known species of the genus, *O. Selwyni*, Salter, from the Arenig terrane of Wales, is not quite so closely related in form to *O.*? *Klotzi* as to the *O. Buchi* from the Llandeilo terrane."

"It is remarkable that a genus showing so little variation from *Ogygia* proper should occur at an horizon so much lower, in an area separated by over 5,000 miles from that in which the genus flourished at a later period in geologic history."

Having regard to the fact that *Ogygopsis Klotzi* differs from *Ogygia* proper in having a well-defined ocular ridge and a narrow palpebral lobe, it seems convenient to separate this Rocky Mountain form generically from the other examples of *Ogygia* as represented by *O. Buchi*, more especially as the latter occurs in beds so much younger than the Middle Cambrian, in which *O. Klotzi* is found (see C. D. Walcott, Proc. U.S. National Museum, 1888, vol. xi, p. 446).

Bathyuriscus Howelli, Walcott, 1886.

Bathyuriscus Howelli, Walcott, 1886: Bull. U.S. Geol. Surv., No. 30, p. 216, pl. xxx, figs. 2, 2*a*.
Embolimus rotundata, Rominger, 1887: Proc. Acad. Nat. Sci. Philad., p. 16, pl. i.
Embolimus rotundatus (Rom.), Walcott, 1888: Amer. Journ. Sci. [3], vol. xxxvi, p. 165; referred to *B. Howelli*.

There are six nearly complete examples of this species (three showing the free cheeks *in situ*, more or less perfectly) and one detached pygidium, all from Mount Stephen, in Mr. Whymper's collection. The figure represents the species one-fourth larger than natural size.

This species might, at first sight, be confounded with junior specimens of *O. Klotzi*, but on closer examination it will be found that there are some important differences. The total length of a specimen of *B. Howelli* is 40 mm.; the head is 13 mm. in length by 25 mm. in breadth, the thorax 17 mm. in length by 23 mm. in breadth, and the pygidium 10 mm. in length by 20 mm. in breadth. The glabella in *B. Howelli* is broader in front (not straight-sided as in *O. Klotzi*), and has four glabellar furrows on each side (not three pairs as in *O. Klotzi*).

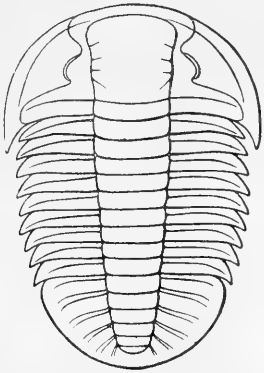


Fig. 2.—*Bathyuriscus Howelli*, Walcott, 1886.
Middle Cambrian: Mount Stephen, B.C. One-fourth larger than nat. size.

The head-shield is very short in proportion to its breadth; the fixed cheeks are narrow, the anterior angle of the eye nearly touching the glabella at its fourth furrow, but expanding again in front, where it surrounds the glabella and forms a rather broad and slightly raised margin to the shield. The ocular border is directed more forward than in *O. Klotzi*, and the latero-posterior margin of the fixed cheek, where it unites with the neck-furrow, is rounded, not acute as in *O. Klotzi*. The neck-furrow and its pleuræ are broad and smooth, and do not carry any tubercles. The free cheeks are rather narrow, and produced backwards into a short and broad spine reaching to the second segment of the thorax. The axis of the body is 8 mm. broad in front and tapers to 5 mm., where the thorax unites with the pygidium, and is 4 mm. broad at the distal end of the pygidium.

There are *nine*[1] thoracic segments in *B. Howelli* and eight in *O. Klotzi*. There are six coalesced segments in the pygidium of this species and eleven in *O. Klotzi*. There are no spines or tubercles on the axis, and the pleuræ of the thoracic segments are straight and moderately pointed backward at their extremities.

Several other species of this genus, which extends from the Middle to the Upper Cambrian (and which was first proposed by Meek in

[1] In Bull. U.S. Geol. Surv., 1886, No. 30, p. 216, Walcott gives the number of thoracic rings as eight; but in Amer. Journ. Sci. [3], 1888, vol. xxxvi, p. 165, he correctly gives the number as *nine*, stating that in the type one segment had been forced beneath the head, a fact that was overlooked in the original specimen. A comparison of specimens from Mount Stephen with the type from Pioche, Nevada, shows them to be specifically identical.

1873) have been described, viz., *B. Haydeni, B. parabola, B. productus*; the last-named may possibly be identical with *B. Howelli*, described here.

Dr. G. F. Matthew has added another species from Mount Stephen, B.C., *Bathyuriscus pupa*, Matthew (1899), Trans. Roy. Soc. Canada, vol. v, p. 51, pl. ii, fig. 5.

BATHYURISCUS (KOOTENIA) DAWSONI, Walcott.

Bathyuriscus (*Kootenia*) *Dawsoni*, Walcott, 1888: Proc. U.S. Nat. Mus., vol. xi, p. 446. Middle Cambrian: Mount Stephen.
Bathyuriscus (*Dorypyge*) *Dawsoni* (Walcott), Matthew, 1899: Proc. & Trans. Roy. Soc. Canada [2], vol. v, p. 56, pl. iii, fig. 1.

M. Cambrian: Mount Stephen. (Not in Whymper Collection.)

BATHYURISCUS PUPA, G. F. Matthew, 1899.

Bathyuriscus pupa, G. F. Matthew, 1899: Proc. & Trans. Roy. Soc. Canada [2], vol. v, p. 51, pl. ii, fig. 5.

M. Cambrian: Mount Stephen. (Not in Whymper Collection.)

NEOLENUS SERRATUS, Rominger, sp., 1887.

? *Olenoides Nevadensis*, Meek, 1877: U.S. Geol. Expl. 40th Par., Palæontology, vol. iv, p. 25.
? *Olenoides Nevadensis*, Walcott, 1886: Bull. U.S. Geol. Surv., No. 30, p. 181, pl. xxv, fig. 7.
Ogygia serrata, Rominger, 1887: Proc. Acad. Nat. Sci. Philad., p. 13, pl. i, figs. 2, 2*a*.
Olenoides Nevadensis, Walcott, 1888: Proc. U.S. Nat. Mus., vol. xi, p. 443.
Olenoides Nevadensis, Walcott, 1888: Amer. Journ. Sci. [3], vol. xxxvi, p. 165.
Neolenus serratus (Roem., sp.), G. F. Matthew, 1899: Trans. Roy. Soc. Canada, pp. 52–54.

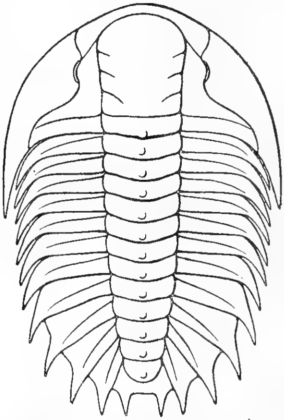


FIG. 3.—*Neolenus serratus*, Rominger, sp., 1887.
Middle Cambrian: Mount Stephen, B.C. Drawn rather less than nat. size.

In Mr. Whymper's collection there are two nearly complete examples and several pygidia of this well-marked species, with which it is probable *N. granulatus*, Matthew,[1] may also be associated,

[1] G. F. Matthew, "Studies on Cambrian Faunas": Trans. Roy. Soc. Canada, 1899, p. 55, pl. ii, figs. 1*a–c*.

but of this species I have not seen the original specimen, only the figure. Dr. G. F. Matthew (op. cit.) is probably justified in separating this form from *Olenoides*, but it is very difficult to decide whether the imperfect specimen figured and described by Walcott as the *Olenoides Nevadensis* of Meek is identical with Rominger's *O. serrata*.

Length of largest entire specimen in Mr. Whymper's collection 6 cm., breadth 4 cm. (Dr. Rominger gives the size of his specimen as 7 c. long and 5 c. wide.) The head is 21 mm. long, the seven free and movable thoracic somites also 21 mm. long, and the pygidium 17 mm. long; the glabella is 13 mm. broad at the cervical furrow, and increases 15 mm. in breadth in front. Three lateral furrows divide the glabella into four lobes on each side; the fixed cheeks form a frontal border separating the glabella from the margin of the head-shield, which is slightly raised; they (the fixed cheeks) are broader near the front of the head, and contract slightly in front of the eyes, when they expand again to form the ocular lobes; then, after a slight contraction, they expand to form an acute angle laterally in uniting with the pleuræ of the cervical ring. The free cheeks are somewhat narrow, and produced to form the lateral spines of the head-shield, which extend backwards to the fourth segment; the eyes are small and narrow, and unite with the glabella by a distinct ocular ridge at their front angles. The axis of the neck-furrow is as broad as one of its pleuræ; the seven free thoracic rings have a strongly marked axis, which gradually diminishes from 13 mm. behind the neck-lobe to 9 mm. in front of the pygidium; the pleuræ are as wide as the axis, broad and flat, with a strongly marked pleural groove, and at the fulcral point, which is clearly marked, their extremities are bent sharply back, and are produced into spines which overlap one another and become slightly broader posteriorly; the five coalesced somites of the pygidium are much expanded and end in strong marginal spines. There is a central tubercle (or, according to Rominger, a short spine) upon the axis of each somite and five upon the pygidium. The hypostome (figured by Rominger) is rounded shield shape (see op. cit., pl. i, figs. 2*b*, *c*).

"The species," says Dr. G. F. Matthew, "included in the new genus (*Neolenus*) are closely related to *Parabolina* (Salter, 1849); they differ chiefly in having a longer pygidium and shorter thorax; also the eye-lobes are placed further back and the marginal fold is wider."

After a comparison of Dr. Matthew's figures of *Parabolina* (in Fauna of St. John's Group, Trans. Roy. Soc. Canada, 1891, vol. ix, p. 51, pl. xiii, fig. 5), I am led to the conclusion that the St. John's specimens are too fragmentary for comparison with our Mount Stephen examples, and do not assist in arriving at such a conclusion. Nor can the present species be placed, as Dr. Rominger believed, near to *Ogygia Klotzi*, save as one of an already well-differentiated group of genera and species of Cambrian Trilobites.

NEOLENUS GRANULATUS, Matthew, 1899.

Neolenus granulatus, G. F. Matthew, 1899: Trans. Roy. Soc. Canada [2], vol. v, p. 55, pl. ii, figs. 1*a–c*.

(Very near to, if not identical with *N. serratus.*) M. Cambrian: Mount Stephen.

PTYCHOPARIA CORDILLERÆ, Walcott, 1888.

Conocephalites Cordilleræ, Rominger, 1887: Proc. Acad. Nat. Sci. Philad., p. 17, pl. i, fig. 7.
Ptychoparia Cordilleræ, Walcott, 1888: Amer. Journ. Sci. [3], vol. xxxvi, p. 165.
Ptychoparia Cordilleræ, G. F. Matthew, 1899: Trans. Roy. Soc. Canada, sect. iv, pp. 44, 45, pl. i, fig. 7.

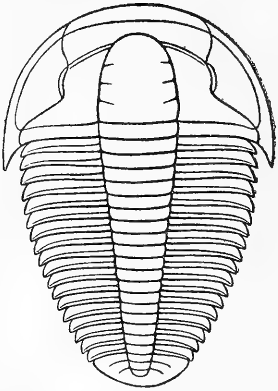


FIG. 4.—*Ptychoparia Cordilleræ*, Rom., sp., 1887.
Middle Cambrian: Mount Stephen and Ball's Valley, B.C. Enlarged 3 times nat. size.

Mr. Whymper's collection affords twelve specimens of this little Trilobite, seven of which are from Ball's Valley and five from Mount Stephen, B.C. Walcott states that he has seen a specimen of this species (*Ptychoparia Cordilleræ*) from Mount Stephen, 23 mm. in length, which had nineteen thoracic segments, agreeing in this respect with *Ptychoparia Piochensis* of Walcott, from the same horizon at Pioche, Nevada. The head is, however, unlike the other species, being more closely related to *P. Kingi* of Meek. (Amer. Journ. Sci. [3], 1888, vol. xxxvi, p. 165.)

G. F. Matthews says: "There appears to be some variation in the number of joints in the thorax; Dr. Rominger enumerates from 14 to 17, but the lower numbers were probably mutilated individuals. . . . . The author has found 18 as a constant number in examples 16 mm. in length and upwards to the adult." The relative number of segments and the length in *Ptychoparia Cordilleræ* are thus shown:—(Walcott), one specimen, 23 mm. long, with 19 thoracic segments; (Matthew), several specimens, 16 mm. long and upwards to adult, 18 thoracic segments (constant); (Rominger), several specimens, 25 mm. average length, 17 thoracic segments, but in two specimens one had 14 segments and one 15 thoracic segments. Of eleven specimens in the Whymper Collection three had 12 segments, four had 13, one had 14, one had 15; and two had 18 thoracic segments. I think the number of segments must therefore be considered inconstant, or that an examination of a larger number of specimens may prove the existence of a second species broader and shorter than *Ptychoparia Cordilleræ*.

The glabella is tumid, but rather narrower and rounded in front, with three marginal furrows; the fixed cheeks surround it in front, the border being bent upwards and forming a strong raised rim; fixed cheeks are very broad in front; eye-lobe short, distant from the glabella, but united to it by a well-marked ocular ridge; free cheeks narrow, with bluntly pointed lateral spines which extend backwards only to the second free thoracic segment; axis equal to one-third the breadth of body-segments in front, but tapering gradually from 4 mm. at the neck-furrow to 1 mm. at the pygidium; pleuræ parallel, but little curved, fulcral groove deep, margins of pleuræ raised; pygidium very small, consisting of three coalesced segments; the axis extends nearly to the extremity; two pairs of lateral furrows faintly mark the pleuræ in the shield.

I have not been able to detect the granulated ornamentation observed by Dr. Matthew in this Trilobite, nor the row of low tubercles on the median line of the thorax. Whether the ornament can be seen or not depends so much upon the fineness or roughness of the matrix in which these small fossils are preserved.

Dr. Matthew observes that among the Trilobites of the fauna of Mount Stephen *Ptychoparia* is the only one which has a specially Lower Cambrian aspect. The genus is now a very extensive one, and has absorbed a great number of species formerly referred to *Conocephalites*, but certainly the whole of the latter genus does not belong to *Ptychoparia*.

Zacanthoides (Olenoides) spinosus, Walcott, 1886.

Olenoides spinosus, Walcott, 1886: Bull. U.S. Geol. Surv., No. 30, p. 184, pl. xxv, figs. 6, 6*a*.
Embolimus, Westwood, 1883: Phil. Mag., ii; a genus of Hymenoptera.
(*Embolimus*) *spinosa*, Rominger, 1887: Proc. Acad. Nat. Sci. Philad., p. 15, pl. i, fig. 3.
Zacanthoides spinosus, Walcott, G. F. Matthew, 1899: Proc. & Trans. Roy. Soc. Canada [2], vol. v, p. 57.
Zacanthoides spinosus, Walcott, 1888: Amer. Journ. Sci. [3], vol. xxxvi, pp. 164–5.

Only one poorly preserved example (impression and counterpart) of this interesting form has been brought home by Mr. Whymper; but by the great kindness of Drs. Whiteaves and Ami I have been allowed to see four excellent specimens, one with a fine head, selected from the collection of the Geological Survey of Canada, in Ottawa, made by Dr. Ami and others from Mount Stephen.

The specimen is 55 mm. long and 35 mm. broad across the head; length of head, 17 mm.; length of thorax, 23 mm.; length of pygidium, 15 mm.

The glabella is large, moderately convex, sides nearly straight, very slightly expanded in front, reaching close to the anterior margin of the cephalic shield, which forms a narrow raised rim. There are four well-marked glabellar furrows, the hinder pair being the largest, and running obliquely backwards, the third and fourth pairs curve forwards towards the front of the glabella.

The axis of the cervical (or occipital) ring is slightly indented on each side on its anterior margin, and there is the raised base of a central spine, directed backwards, as in other Onellidæ, although the spine itself is wanting. The side-lobes or pleuræ of the cervical ring are short and arched, and terminate laterally in a small stout spine directed outwards and backwards, and lying well within the great lateral spines of the free cheek. The fixed cheek has a wide, semicircular expansion on each side of the glabella above the eye, reaching from the cervical furrow behind to the fourth furrow on the glabella in front, the eye itself making a long narrow rased border to the fixed cheek. The facial suture nearly touches the glabella in front, and then bends slightly outwards in a curved line until it reaches the anterior margin of the head-shield.

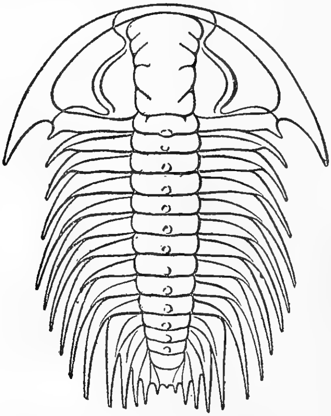


Fig. 5.—*Zacanthoides* (*Olenoides*) *spinosus*, Walcott, 1886.

The head (in *Zacanthoides*) forms the broadest portion of the Trilobite, the spines of the free cheeks being directed very much outwards as well as backwards, and measuring 42 mm. across. Their points do not reach further back than the second free somite. There are nine free thoracic somites, the extremities of which form long, sharply recurved spines, overlapping each other and increasing in length from the head to the pygidium, the hindmost being more than twice as long as the pleura itself; the pleuræ diminishing rapidly in breadth from before backwards as their spines increase in length.

The pygidium has four distinct coalesced annuli with a terminal plate fringed by three small spines. The spines of the four abdominal or pygal segments correspond with those of the pleuræ, but they diminish very rapidly to the extremity of the tail. The axis of all the free thoracic segments and perhaps the first of the coalesced caudal segments appear to have each supported a central spine, as in *Zacanthoides typicalis, Olenellus* (*Holmia*) *Kjerulfi,* Holm, *O. Gilberti,* Walcott, *Olenellus Callavei,*[1] *O.* (*Holmia*) *Bröggeri,* and many other Cambrian forms of Trilobites.

If one is surprised to find a genus such as *Ogygia Buchi* in the Llandeilo Flags of Builth represented in the still earlier Middle Cambrian fauna by *O. Klotzi* at Mount Stephen, B.C., it is equally remarkable to find *Zacanthoides spinosus* at Mount Stephen, B.C., and *Z.* (*O.*) *typicalis* (in Middle Cambrian), Pioche, Nevada, U.S.A., so closely resembling and preceded by such a form as *Olenellus* (*Holmia*) *Kjerulfi* in the Lower Cambrian of Norway,[2] which, although belonging to another genus, was clearly an ancestral form.

Concerning the genus *Embolimus* Mr. Walcott writes[3]:—"The generic name *Embolimus* was given by Westwood to a genus of Hymenoptera in 1833. It was spelt *Embolemus* by Westwood, and was corrected by Professor Agassiz to *Embolimus* in his Nomenclator Zoologicus.

"The first species named under this genus by Dr. Rominger, *Embolimus spinosa,* was described as *Olenoides spinosus* in 1886, and the second species, *Embolimus rotundatus,* as *Bathyuriscus Howelli.*

"When studying the Georgina fauna in 1885, I found that the genus *Olenoides* was probably the same as the genus *Dorypyge* of Dames. Wishing more material for comparison I left all the species under the genus *Olenoides.* A large, fine species of the genus *Olenoides* was collected in the Cambrian shales of Northern Alabama in 1886, which proved conclusively that *Dorypyge* was founded on a species congeneric with the type of *Olenoides.* I then recognized that the species *Olenoides typicalis, O. spinosus, O. levis,* and *O. flagricaudatus* formed a distinct generic group, which I was preparing to illustrate when Dr. Rominger's paper appeared. As the generic name proposed by him is preoccupied I suggest the name *Zacanthoides,* including in it *Z. typicalis, Z. spinosus, Z. levis,* and *Z. flagricaudatus.* The species remaining under *Olenoides* are *O. Nevadensis, O. Marconi, O. quadriceps,* and *O. Wasatchensis.* After comparing specimens I found that *Embolimus spinosa,* Rom., = *Zacanthoides spinosus,* Walcott; *Embolimus rotundata,* Rom., = *Bathyuriscus Howelli,* Walcott; *Ogygia serrata* = *Olenoides Nevadensis,* Meek; and that the last two, *Conocephalites Cordilleræ,* Rom., = *Ptychoparia Cordilleræ,* Rom. (sp.), and *Ogygia*?? *Klotzi,* Rom., are new additions to the previously known Cambrian fauna."

[1] *Olenellus Callavei,* Lapworth: Geological Magazine, 1891, pp. 529–536, Pls. XIV and XV.
[2] G. Holm, "On *Olenellus Kjerulfi*": Foren. Forhandl., 1887, Bd. ix.
[3] C. D. Walcott, "Cambrian Fossil from Mount Stephen, N.W. Territory of Canada": Amer. Journ. Sci. [3], 1888, vol. xxxvi, pp. 161*–166.

ORYCTOCEPHALUS, Walcott, 1886.

Bull. U.S. Geol. Surv., 1886, No. 30, p. 210.

1. Oryctocephalus Walkeri, G. F. Matthew, 1899.

Studies on Cambrian Faunas, No. 3: Trans. Roy. Soc. Canada, 1899, p. 60, pl. iii, fig. 2.

M. Cambrian: Mount Stephen, B.C. (Not in the Whymper Collection.)

2. Oryctocephalus Reynoldsi, F. R. Cowper Reed, 1899.

Geol. Mag., Dec. IV, Vol. VI, pp. 358–361.

M. Cambrian: Mount Stephen, B.C. (Not in the Whymper Collection.)

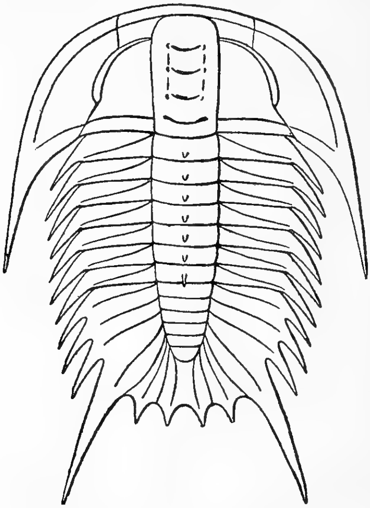


Fig. 6.—*Oryctocephalus Reynoldsi*, F. R. Cowper Reed, 1899.[1]
Middle Cambrian: Mount Stephen, B.C. (Original specimen in the Woodwardian Museum, Cambridge.)

This form has been fully described in this Magazine, Dec. IV, Vol. VI, 1899, pp. 358–361.

Conocephalites (Conaspis ?) cf. perseus, Hall, 1862.

Conocephalites (*Conaspis*) *perseus*, Hall, 1862: Prelim. Rep. Fauna Potsdam Sandstone, Albany.

Conocephalites (*Conaspis* ?) *perseus*, Hall, G. F. Matthew, 1899: Proc. & Trans. Roy. Soc. Canada [2], vol. v, p. 46, pl. ii, fig. 4.

(Glabella and fixed cheeks only.) M. Cambrian: Mount Stephen.

Corynexochus Roemingeri, Matthew, 1899.

Corynexochus Roemingeri, G. F. Matthew, 1899: Proc. & Trans. Roy. Soc. Canada [2], vol. v, p. 47, pl. ii, fig. 3.

(Glabella and fixed cheeks only.) M. Cambrian: Mount Stephen.

[1] Refigured here by permission of the author.

DOLICHOMETOPUS OCCIDENTALIS, Matthew, 1899.

Dolichometopus occidentalis, Matthew, 1899: Proc. & Trans. Roy. Soc. Canada [2], vol. v, p. 49, pl. ii, fig. 2.

Only one example known (12 mm. long by 8 mm. wide).

Referred by Matthew to Angelin's genus *Dolichometopus*, of which only the head is known from Sweden.

(Unique.) M. Cambrian: Mount Stephen.

AGNOSTUS INTERSTRICTUS, White.

Probably there are several species of *Agnostus* from Mount Stephen. *A. interstrictus* is certainly found there.

"This species," says Walcott, "is very abundant at Antelope Spring, Utah, where it is associated with *Olenoides Nevadensis*, as at Mount Stephen." (Amer. Journ. Sci. [3], 1888, vol. xxxvi, p. 166.)

Whymper Collection.

AGNOSTUS MONTIS, Matthew, 1899.

Agnostus montis, Matthew: Trans. Roy. Soc. Canada, vol. v, p. 43, pl. i, fig. 6.
Agnostus cf. *integer*, Barr., 1887: Roeminger, Proc. Acad. Nat. Sci. Philad., pt. i, p. 18, pl. i, fig. 9.

M. Cambrian: Mount Stephen, B.C.

(Collected by Byron Walker, Esq., F.G.S.) Geol. Surv. Museum, Ottawa. Mr. Walcott writes[1] as follows:—

"*Hyolithellus micans*, Billings.—Black, shiny, concentrically striated or smooth, compressed tubes occur in the shale with the Trilobites, that appear to be identical with *H. micans* of the Middle Cambrian fauna of New York, Vermont, and Canada. These 'slender stems,' mentioned by Dr. Rominger, may be the same as the slender shells of this species which appear like compressed stems formed of shiny carbonaceous matter."

"It is doubtful what the specimen identified as *Monocephalus Salteri*? is. It may be the young of *Bathyuriscus Howelli*. The specimen figured as *Bathyurus*? is too badly defined to identify it. Of the remaining genera mentioned by Dr. Rominger I do not find any traces in the material before me with the exception of a fragment of *Orthis*."

"*Kutorgina Prospectensis*, Walcott?—A fragment of a species of *Kutorgina*, closely related to *K. Prospectensis*, occurs on the slate in association with *Ptychoparia Cordilleræ*. It is not improbable that it represents a new species."

Among the specimens obtained by Mr. Whymper from Ball's Valley, 23 miles distant from Field, may be mentioned *Ogygopsis Klotzi*, *Bathyuriscus Howelli*, *Ptychoparia Cordilleræ* (seven specimens), *Agnostus interstrictus*, *Stenotheca rugosa*, etc.

Dr. J. F. Whiteaves, F.G.S., Palæontologist to the Geological Survey of Canada, gives in *The Canadian Record of Science*, 1893, vol. v, pp. 205–8, a figure and description of a new genus and species of Phyllocarid Crustacean from the Middle Cambrian of Mount Stephen, B.C., of which Mr. Edward Whymper also secured four examples, one of which is figured here.

[1] Amer. Journ. Sci. [3], 1888, vol. xxxvi, p. 165.

Anomalocaris (gen. nov.).—"Carapace and its appendages unknown or too obscurely indicated for their characters to be defined; body many jointed and consisting of not less than nine to thirteen segments, exclusive of the caudal segment; ventral portion of each of the body-segments bearing a pair of slender, narrowly elongated and acutely pointed, simple and probably branchial appendages, of the nature of uropods, or foot-gills (?); posterior terminal segment margined with three pairs of caudal spines, one terminal and the other two lateral; the posterior pair of uropods represented in the woodcut apparently belonging to a pre-caudal segment whose posterior boundary has been obliterated.

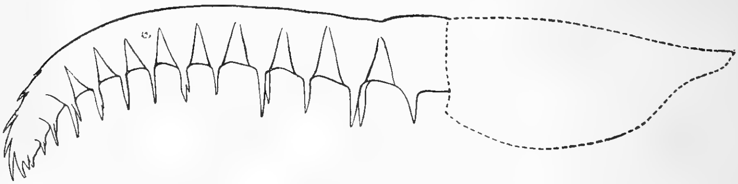


FIG. 7.—*Anomalocaris Canadensis*, Whiteaves (1892). Three-fourths nat. size (anterior part of carapace conjectural). Drawn by Miss G. M. Woodward from a specimen in very dark shale from the Middle Cambrian of Mount Stephen, obtained by Edward Whymper, Esq., F.R.G.S., in 1901.

"Body, inclusive of the tail, elongated, slender, decreasing slowly in size from the anterior to the posterior end, rather strongly curved posteriorly and nearly straight anteriorly, the length of the portion preserved varying in different specimens from nine to ten centimetres (as measured at from about the mid-height and following the curve of each), and the height or depth at the imperfect anterior end from twelve to seventeen millimetres, exclusive of the ventral appendages. Body or abdominal segments, which in all the specimens collected are abnormally flattened laterally, a little higher or deeper than long, broader above than below; the pair of ventral appendages are straight and prolonged downward at almost a right angle to the main axis of the body, for although there is a slight divergence in each pair, neither are directed distinctly backward nor forward. Between each pair of segments there is evidence of a wedge-shaped or very narrowly triangular lateral area or interval,[1] which is broadest or widest below and does not seem to extend quite to the dorsal margin. At the posterior end the segmentation is very obscurely defined. Caudal spines, which are simple, slender, longitudinally elongated, and acutely pointed, averaging 6 mm. in length by about 1 mm. in breadth at the base; the three pairs of spines about equal in length, though the two lateral ones are placed farther forward than the central and terminal pair. Surface markings entirely unknown.

"This genus and species are based upon upwards of fifty specimens

[1] This space appears to have been occupied by a membranous connection which united the harder tergal portion of each somite to its fellow; the integument, however, must have been very thin, probably like that of *Apus* and *Branchipus*.

collected from a band of shale of Middle Cambrian age at Mount Stephen, near Field Station on the Canadian Pacific Railway. Two of these specimens were collected by Mr. R. G. McConnell, of the Geological Survey of Canada, in 1888, and the remainder by Dr. H. M. Ami, of the same Survey, in 1891. The species seems to have been somewhat gregarious in its habits when living, for upwards of twenty specimens of it are exposed on the surface of a large slab of shale collected by Dr. Ami at this locality, and fourteen upon that of another. It is associated with numerous species of Trilobites, Brachiopoda, etc. All the specimens of *A. Canadensis* are crushed quite flat laterally, and occur as obscurely defined and extremely thin carbonaceous impressions of the body-segments, with the tail (the latter usually a little twisted) on each of the surfaces exposed by splitting pieces of the shale.

"The generic name *Anomalocaris* (from *ἀνομοιος*, 'unlike'; *καρις*, 'a shrimp'; i.e. unlike *other* shrimps) is suggested by the unusual shape of the uropods or ventral appendages of the body-segments and the relative position of the caudal spines.

"Ten genera of Phyllocarida have previously been recorded as occurring in the Cambrian rocks of Europe or America. These include *Ceratiocaris*, McCoy (1848), *Hymenocaris*, Salter (1853), and *Protocaris*, Walcott (1884). To these may now be added *Anomalocaris*, which differs from the other three genera of Cambrian Phyllocarids in the following particulars:—In *Ceratiocaris* the caudal appendages consist of a median telson or style and two lateral stylets. Further, although ventral appendages to the body-segments have been discovered in one species of *Ceratiocaris*, the *C. stygia* of Salter, yet these are represented as 'broad and paddle-shaped,' not slender and acutely pointed[1] as in *Anomalocaris*. In *Hymenocaris*, according to Professor H. A. Nicholson, the 'hinder termination of the body is adorned with three pairs of unequal spines,' but in the woodcut of the type and only known species of that genus, the *H. vermicauda*, which is reproduced in so many palæontological manuals, all of these spines are represented as terminal and the body-segments as devoid of any ventral appendages. The first specimens of *Hymenocaris*, by the way, were collected by Dr. Selwyn in 1846 in the Lingula Flags near Dolgelly, Merionethshire. The *Protocaris Marshii* of Walcott, from the Middle Cambrian of Vermont, is described as having no fewer than thirty narrow segments 'between the posterior edge of the carapace and the telson,' and a telson 'which supports two caudal spines.'" (J. F. W.)

We are prevented by want of space from giving, as we had hoped to do, a complete summary of the Mount Stephen fossils, and must here conclude our imperfect sketch of this most interesting fauna, expressing the hope that the Canadian Geological Survey will before long publish the whole series in a monograph form.

[1] After a careful study of Mr. Whymper's specimens I am inclined to think these acutely pointed and spine-like appendages may have been fringed with fine hairs, of which I have here and there detected traces.

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1887. R. G. McConnell (Geol. Surv. Canada).—"Report on the Geology of a portion of the Rocky Mountains" (with Section): Ann. Rep., new ser., vol. ii (1886), pp. 1D–41D; Montreal, 1887. "*Olenellus Gilberti*, Walcott (Middle Cambrian), Vermillion Pass (1884), collected by Dr. G. M. Dawson": op. cit., p. 30D.

1887. Dr. C. Rominger.—"Description of Primordial Fossils from Mount Stephens, North-West Territory of Canada": Proc. Acad. Nat. Sci. Philadelphia, 1887, pp. 12–19, pl. i, with descriptions of seven Trilobites from Mount Stephen.

1888. Chas. D. Walcott.—"Description of New Genera and Species of Fossils from the Middle Cambrian": Proc. U.S. National Museum, Washington, 1889 (vol. xi, 1888), pp. 441–446, with descriptions of thirteen fossils, mostly from Mount Stephen.

1890. Chas. D. Walcott.—"The Fauna of the Lower Cambrian or *Olenellus* Zone," in 10th Ann. Rep. U.S. Geol. Surv., 1888–9, by J. W. Powell, Director; pt. i, Geology, pp. 511–658, pls. xliii–lxxvi. Page 538 refers to Dr. G. M. Dawson's discovery of *Olenellus Gilberti*, etc., etc.

1886. Chas. D. Walcott.—"The Cambrian Faunas of North America": Bull. U.S. Geol. Surv., vol. iv (1885–6), pp. 1–226, pls. i–xxxiii.

1888. Chas. D. Walcott.—"Cambrian Fossils from Mount Stephens, North-West Territory of Canada": Amer. Journ. Sci., ser. iii, vol. xxxvi (Sept., 1888), pp. 161–166.

1892. J. F. Whiteaves, LL.D., F.G.S.—"Description of a New Genus and Species of Phyllocarid Crustacean from the Middle Cambrian of Mount Stephen, B.C.": Canadian Record of Science, vol. v, No. 4 (Oct., 1892), pp. 205–208, with a text-figure of *Anomalocaris Canadensis*.

1899. G. F. Matthew, D.Sc., LL.D.—"Studies on Cambrian Faunas, No. 3. Upper Cambrian Fauna of Mount Stephen, British Columbia: The Trilobites and Worms": Proc. & Trans. Roy. Soc. Canada, ser. ii, vol. v (1899), sect. iv, pp. 39–66, pls. i–iii, vii.

1899. F. R. Cowper Reed.—"A New Trilobite from Mount Stephen, Field, B.C.": Geol. Mag., Dec. IV, Vol. VI (1899), pp. 358–361, with a text-figure of *Oryctocephalus Reynoldsi*, sp. nov.

1902. Professor T. G. Bonney, F.R.S.—"A Sodalite Syenite from the Canadian Rocky Mountains": Geol. Mag., 1902, pp. 199–206.

II.—The Canadian Rockies. Part II: On some Rock-specimens collected by E. Whymper, Esq., F.R.S.E., in the Canadian Rocky Mountains.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S.

The Canada Pacific Railway crosses the watershed of the Rocky Mountains at Hector or, as it is sometimes called, Kicking Horse Pass, and the specimens brought back by Mr. Whymper represent a district extending for some twenty miles on each side of the track, either on or west of the divide. The first group was obtained from summits lying near the railway on its southern side. Of these Mount Whyte is about three miles from it on the divide, which is crossed by Pope's Col just to the north of that summit, and about a mile to the north-east of the latter rises Mount St. Piran. About $3\frac{1}{2}$ miles south of Mount Whyte, Mitre Col leads from the Lefroy to the Horseshoe glacier, between Mount Lefroy, which is on the divide, and Mitre Peak on the eastern side of it.

The specimen from the summit of Mount Whyte [2017][1] is

[1] The numbers are those on Mr. Whymper's specimens, which may be understood to have been taken from rock *in sitû*, unless there is an express statement to the contrary.

a nearly white, fairly crystalline limestone, which under the microscope proves to be composed of calcite grains (slightly dolomitic and banded), varying in diameter from about ·0014 to ·025 inch, with a slight brown, feebly pleochroic stain in one or two places, and a few very dark brown specks (? iron-oxide). The fragment from the summit of Pope's Col [2016] is a darkish-grey subcrystalline limestone, weathering to a paler tint, crossed by a thin vein of calcite which slightly projects on a weather-worn surface. Microscopic examination shows it to be a dolomitic limestone composed (except for a slight staining near a vein) of grains fairly uniform in size and often about ·005 or ·006 inch in diameter. The summit of Mount St. Piran [2019] is a rather slabby and banded quartzite of a brownish or purplish grey colour, obviously containing, especially in one band, an iron-oxide which weathers away in brown specks. The microscope shows it to be mainly composed of quartz grains in finer and coarser bands, the former being mostly subangular and often rather less than ·001 inch in diameter. A few grains, however, are a brownish grey colour, and exhibit, with crossed nicols, a minute aggregate structure, possibly resulting from the alteration of felspar; these are from ·025 to ·035 inch in diameter, and usually well rounded. One or two streaky aggregates of chlorite are present, and this mineral can be detected, though seldom, in the last-named grains. There may be a little minute rutile. The quartz cementing the larger grains of the same mineral is in optical continuity with that to which it adheres, though the outline of this is often defined by a line of iron-oxide. Obviously most of the latter was deposited almost simultaneously with the cementing silica. The rock from the summit of Mitre Col [2018] is a rudely prismatic (jointed) fragment of a darkish subcrystalline limestone, with small white spots rather irregular in shape and size. A slice cut parallel with the probable direction of bedding shows a general similarity to that from Pope's Col, except that here and there patches occur composed of grains nearly treble the ordinary diameter, but with no recognizable sign of organic structure. A few dark-brown specks are probably iron-oxide. The summit rock of Mitre Peak [2020] is a rather crystalline, nearly white limestone, somewhat mottled by dull and darkish lead-coloured spots, which is rudely defined by joint and bedding planes. A slice cut perpendicular to the latter shows it to be a crystalline limestone, almost without sign of dolomitization. Grains about ·015 inch in diameter occur in patches, the rest being about half that width. Some small grains and specks of iron-oxide are present.

The next group of specimens come from the neighbourhood of Mount Ball, which rises on the divide a little to the south of Vermillion Pass and about 26 miles S.S.E. of Hector Pass. Of these [2010], [2012], and [2014] come from a valley on the east side of the divide which leads from the north to Mount Ball. The first, labelled "from the great boulder," is a pale-grey subcrystalline limestone, with minute crystals sparkling in a compact matrix, like that of some of the purest British Carboniferous limestones. The second is a dark limestone, probably tinted by carbonaceous matter and not very pure, which assumes a brownish tint in weathering. On one side portions of four trilobites are exposed.[1] The last number covers three specimens from the moraine of the glacier in Ball Valley. One is a rather dark limestone, compact in structure, not unlike some of our Carboniferous limestones, in which are some irregular white spots and occasional white streaks up to about a quarter of an inch in length; a second is not quite so dark, but has only a few small spots; the third (smaller) is a prism with natural faces, paler in colour. These two much resemble specimens of British Carboniferous Limestone. A slice from the first shows a mosaic of grains, rather variable in shape and size, and ranging from about ·0025 to ·005 of an inch in diameter. Most of them are crystalline calcite, but the brighter tints of some suggest the presence of dolomite, or possibly chalybite. The white spots prove to be irregular aggregates of similar but larger grains, often about ·02 inch in diameter. The matrix includes a few crystalline grains of a clear colourless silicate, two of which, about ·025 inch long, are fairly idiomorphic, being bounded by edges in the prism-pinacoid zone, and those of pyramids or domes meeting at an angle of about 70°. They extinguish at a small angle, about 5°, with the former lines, include a few granules of calcite, and probably are a secondary felspar. [2015], from the summit rock of Ball Pass, is a compact darkish limestone, bounded by four rhomboidal joints, and showing at right angles to these slight signs of lamination. Under the microscope this structure is more conspicuous, for it proves to be composed of granules of calcite, with a faint staining, divided by linear bands of grains, about ·0025 inch in diameter, separated by a dark-brown material, and presenting a slightly fragmental aspect. A number of minute cracks, filled with more coarsely crystalline calcite, run at high angles to the banding. This specimen may have been affected by a shearing crush. [2013], from the summit of Mount Francklyn, which rises just north of Vermillion Pass, is an oblong slab, four of its surfaces being natural; apparently it is a compact, rather muddy limestone, a dull grey, weathering brownish, in colour, with a faint and slightly wavy cleavage, which makes an angle of about 25° with the (natural) top and bottom surfaces of the slab.

The next group of specimens comes from the Mount Stephen district. This peak lies a short distance to the E.N.E. of Field (4,026 feet), which is a station on the Canada Pacific Railway a few miles west of the divide. [2011], "from a height of about 6,000 feet on this mountain," is a rather slabby, dark calcareous mudstone, something like Llandeilo Flag, but weathering to a browner tint.[2]

Cathedral Peak [2035], E.N.E. of Mount Stephen (but also west of the divide), is a stratified limestone, the broader bands darkish grey, the thinner weathering to a browner tint, but little streaks with a similar habit occur in the other. Dennis Pass is to the south

[1] For a description of these by Dr. H. Woodward see pp. 536 and 541.

[2] For a description of the fossils on it see Dr. Woodward's paper, pp. 529–543.

of Mount Stephen, between it and Mount Dennis. The rock from the summit [2021] is a flattish slab, formed by a vein of quartz, from about a quarter to nearly half an inch in thickness, slightly iron-stained on both sides, with a little pale greenish-grey phyllite adhering, in which are some more distinctly micaceous streaks, the rock no doubt having been much affected by pressure. On the west bank of the Kicking Horse River, facing Mount Stephen, is Mount Burgess. From the summit one of Mr. Whymper's guides brought a piece of dark grey limestone [2039] resembling one from our Lower Carboniferous. Under the microscope it is found to consist of minute grains of calcite, of a pale brownish-grey tint, in which thin brown lines indicate a rude cleavage; two or three cracks being filled by calcite. It is probably a pressure-modified limestone. From the base of the mountain, about one-third of a mile from Field and nearly at the level of Hector Pass, two specimens were collected from rock exposed in blasting a road to the Emerald Lake. One is a chip of rather dark compact limestone, weathering to a paler tint, not unlike the summit rock; the other is a similar rock, but covered in parts with a tufaceous deposit. Mr. Whymper remarks that round about Field, or, indeed, at most places in the Rockies, which have nearly the same elevation above the sea, it is very difficult to find rock *in sitû*, for it is masked by forest or buried under vast quantities of soil or débris.

The next specimens come from mountains some fifteen miles to the north-west of Field and to the south-west of Mount Collie, or from a mass forming a kind of spur between two tributaries of the Columbia River, namely, Kicking Horse River on the south and Blaeberry Creek on the north. The summit of Mount Marpole [2022] is a dark grey compact limestone, which weathers to a pale brown colour and shows on a polished surface numerous small spherical bodies, of a yellowish-brown colour, often with a greyer central spot, which have some resemblance to the grains of an oolite, but weather out more quickly than the rest of the rock. The matrix under the microscope is formed of calcite grains, perhaps slightly dolomitic, somewhat variable in size and shape, and enclosing a number of rather oval bodies about ·05 inch in longer diameter, commonly composed of an outer shell of grains (diameter about ·001 inch) with an approach to radial arrangement, and a core of smaller grains and granules, with a little interstitial brown colouring (? bituminous). Here and there we find a grain, neither composite nor so large, suggesting, but not conclusively, an organic origin. The rock seems to have undergone a considerable amount of mineral, followed possibly by some mechanical change. The summit of Mount Kerr [2023] is a very similar rock, but with rather smaller and paler-coloured spots, which under the microscope are seen to be approximately spherical and composed of grains of calcite, outlined, and even faintly tinted, by brownish material, embedded in clear granular calcite, much of the same size, a little dolomitic, and showing a slight bending of the cleavage planes, indicative of strain. Probably both these rocks are somewhat altered oolites. Dr. Collie brought back a fragment (loose) with a similar structure from the district considerably farther north. From the foot of these mountains Emerald Pass leads eastwards to Emerald Lake. The rock from its summit [2024] is a pale grey, very compact limestone, like one of the purest English Carboniferous limestones, with rhomboidal jointing, weathering buff colour, and developing a fine, slightly wavy banding. The structure, on microscopic examination, proves to be due to coarser and finer grains of calcite, slightly dolomitic. Two or three irregularly outlined, larger grains are suggestive of an organic origin. Other scattered specks and grains occur, the latter hematite. Mount McNicoll is near Emerald Pass, and its summit [2027] is a greyish limestone, which, from its brown weathering, must contain a fair amount of iron. It has a rather earthy odour and effervesces, but not very briskly, with H Cl, and is probably not very pure. The rock [2028] from the summit of the pass between it and Mount Shaughnessey is not quite so ferruginous as the last, but otherwise is in all respects similar. The summit of Michael's Mount [2029], part of the same massif, is a cream-grey subcrystalline limestone, with faint rust-brown spots and a few irregular patches of a darker grey colour. The structure proves on microscopic examination to be rather irregular. Grains of calcite, occasionally dolomitic, differing considerably in size and arrangement, predominate; the larger sometimes forming little clusters with a pale-brown staining, which vary from rather irregular to oval in outline, and sometimes grouped in a way suggestive of the former presence of fragments of shells, etc. Rather irregularly distributed among this, and sometimes aggregated, are small grains of a clear silicate, a few of which are partly idiomorphic and exhibit twinning, Carlsbad or oscillatory. Probably they are a secondary felspar, and a few dark specks are iron-oxide.

Nearer to Mount Collie, on the north side of the Upper Yoho Valley, are the following peaks: Mount Pollinger [2025], Mount Kaufmann [2026], Insulated Peak [2030], and Yoho Peak [2032]. The summit of the first is a pale-grey subcrystalline limestone, with some resemblance to one of the dolomitic limestones of the Alps, but becoming browner on weathered surfaces. Mount Kaufmann is a grey limestone, showing thin bands differing in texture from the rest, and projecting slightly from weathered surfaces. Insulated Peak is a subcrystalline limestone of a grey colour, slightly streaked with white, and showing faint traces of small spots, which weather brown. Under the microscope it is found to consist of grains (a large number being about double the size of the others), more or less dolomitic, of a faint brown colour, with a slight pleochroism in which, as a matrix, are occasional irregular stain-like spots of a dirty brown colour (? bituminous). There are also a few minute interstitial granules of a water-clear silicate, and the rock more nearly than usual approaches to a marble. Yoho Peak is a grey subcrystalline limestone, assuming a buff tint on weathered surfaces and veined with calcite. The summit of Trolltinderne, a mountain on the eastern side of the Yoho Valley and just west of the watershed, is a rather dark grey limestone, with moderate effervescence, showing on a smooth surface a rudely banded, almost fluxional structure in the form of darker and lighter streaks. Microscopic examination proves it to be a mixture of dirty granular calcareous material, and of a less abundant clear silicate in small grains, and a few flakes, probably of white mica, with sundry brown and blackish specks like iron-oxide; the whole traversed by rather irregular dark lines, indicative of a rude cleavage. The clear silicate sometimes includes very minute rhomboidal scales, and as one or two grains of it show a distinct oscillatory twinning, it is probably a plagioclastic felspar. The glacier which feeds the Yoho River descends from Mount Collie [2033] and Mount Habel [2031], a summit about 1½ miles to the south-west of the other. The summit of Mount Collie is a compact, subcrystalline, not very dark grey limestone, weathering to a browner tint, with faint traces of minute spots which become more conspicuous by forming holes on a weathered surface. As effervescence with H Cl is slower than one would anticipate, the specimen is probably dolomitic. The summit of Mount Habel is a grey subcrystalline limestone, full of very small spots, rather irregularly distributed, and weathering to a pale brown colour, containing also a few white calcitic grains without definite form or size, the largest of which are about ·2 inch in diameter. The microscope shows it to be a rather dolomitic limestone, with occasional coarser spots and little patches of brown staining. Here and there the former presence of an organism is suggested, and some rather cylindrical clear bodies, in which granules of the carbonate are embedded, have a very faint resemblance to sponge spicules. Extinction is parallel to the edges, so that if only mineral in origin they may be allied to couseranite.

The specimens from the Ice River Valley, chiefly crystalline rocks and in many cases sodalite or nepheline syenite, have been already described in the Geological Magazine for this year (p. 199).

Specimens from the Hoodoos (earth pillars) of Leanchoil (on the Canada Pacific Railway) [2040] are a pale yellowish clay and a small grey limestone pebble, clearly water-worn, but not in any way remarkable. The former consists of minute micaceous and clayey material, mixed with small angular rock-fragments, stained a rather rusty tint, and difficult to determine exactly — not improbably a siliceous mudstone. Few, if any, quartz grains occur in the mud, which otherwise is not remarkable. It effervesces slightly with H Cl, so the material is probably derived from argillites and limestones.

The above descriptions show that [2107] and possibly [2020] approach the structure of a true marble, such as that of Carrara, or one of those interbanded with crystalline schists in the Alps. Most of them are not more altered than specimens from the Dolomites of the Italian Tyrol (to which one or two of them have some resemblance) or than some of the Triassic rocks from the Swiss Alps. Others resemble Carboniferous Limestone from Britain, and the Trilobites from near Mount Ball and from the flank of Mount Stephen are in excellent preservation. But, though I have sliced practically every specimen of limestone which seemed at all likely to contain fragments of organisms, not a single one has yielded anything of which I could be sure. Yet I have found these in very disturbed districts of the Alps, not only in the noted schistose Jurassics of the Lepontine group (containing belemnites, crinoids, etc.[1]), but also in Triassic limestones near Bergün. With one exception (and this may be due to contact metamorphism, such as must occur in the Ice River Valley), these specimens apparently are not older than Palæozoic times, and in some cases might even be Mesozoic. Hence, as the limestones are numerous, the absence of organisms is so singular that I can only suppose they have disappeared in consequence of micromineralogical changes, as, I believe, has happened with a Triassic limestone near the Pas de Chèvres, Arolla, of which I was more than once reminded by some of these specimens.

III.—The Geology of Barbados.

By Prof. J. B. Harrison, C.M.G., F.G.S., and A. J. Jukes-Browne, B.A., F.G.S.

The August number of the Quarterly Journal of the Geological Society contains a paper on this subject by Dr. J. W. Spencer, who believes that the rocks which were described by us under the head of 'Raised Coral Reefs'[2] do not form one continuous succession of Pleistocene reef-rocks, but consist of several different limestone formations. He thinks that there are three such formations, and that each is separated from the other by a break or unconformity.

It is, of course, quite possible that the more recent reefs may partially conceal a formation which escaped our notice, and that Dr. Spencer might have obtained evidence of its existence; but before he can establish the existence of an Oligocene limestone in or below some part of our Coral Reef Series, and as a consequence alter the accepted age of every rock-group in the island, he must produce very strong evidence for his innovation.

We fail to find any such evidence in his paper; thus, the only evidence for the Oligocene age of any of our 'reef-rocks' is the occurrence of two corals, unnamed species of *Stylophora* and *Astrocœnia*, which are said by Dr. T. W. Vaughan to be the same species as occur in a limestone of Oligocene age in Antigua. These were only found at one place, a spot near the Cathedral at Bridgetown, and this is absolutely all the palæontological evidence which Dr. Spencer has to offer in support of his conclusion that there are Oligocene limestones in Barbados comparable with those of Antigua.

Beds exposed in a railway cutting not far from Ragged Point, on the eastern side of the island, are referred to this Oligocene formation solely because they show an apparent dip of 15° to 20° and pass below a later horizontal calcareous deposit. No fossils are recorded either from the newer or the older rock, but it is stated that the latter includes a bed which contains masses of corals.

[1] Quart. Journ. Geol. Soc., 1890, vol. xlvi, p. 213.
[2] Quart. Journ. Geol. Soc., 1891, vol. xlvii, p. 209.

Specimens were taken by Dr. Spencer, but they were unfortunately destroyed by accident before they could be named.

Finally, all the higher reefs are considered to be of Oligocene age, because the author says that they show a decided dip to the south-east, and asserts that some of the fossils obtained by ourselves and others are Oligocene species. His own collections were destroyed as above-mentioned, and his statements about the range of the species identified by Professor Gregory [1] are confused and inaccurate. Professor Gregory identified 13 species of Corals from high-level localities, and of these 11 belong to recent species (10 being also found in the low-level reefs of the island); one is a new species for which the only other locality yet known is Ste. Croix in Trinidad, and one (*Lamellastræa Smythi*) is an extinct Antiguan species.

It is true that several of the species found in Barbados occur also in the Antiguan limestones which Dr. Spencer refers to the Oligocene, but as they are also recent West Indian corals they cannot be cited as evidence for the Oligocene age of the Barbadian reefs; clearly such species might occur in beds of any age from the Oligocene to the present time. *Cyphastrea costata* is one of these; Dr. Spencer also quotes *Astræa barbadensis* (Duck. & Mich.) as a link between the 'Oligocene' rocks of the two islands, but Professor Gregory has identified this form with *Orbicella acropora* (Linn.), which is a recent West Indian coral and is found also in the low-level reefs of Barbados.

Dr. Spencer admits that the assemblage of corals obtained from the high-level reefs is sufficient to prove the existence of Pleistocene reefs at such levels, but having persuaded himself that there is a mixture of Pleistocene and Oligocene forms among them, he actually explains this supposed mixture by suggesting that the Pleistocene forms came from patches of Pleistocene reef-rock lying in hollows or pockets excavated out of Oligocene limestones!

As the corals examined by Professor Gregory came from nine different high-level localities, Dr. Spencer would have us believe that in each case a pocket was rifled, and not what he imagines to be the main limestone mass. If he had been more careful in his analysis of the coral species he would have discovered that the single restricted Oligocene species was obtained from only one locality, namely, Castle Grant, but he was so convinced that the mass of the high-level limestones must be of Oligocene age that he throws doubt on all the localities and on all the collections that have been previously made, in spite of the fact that no essentially Oligocene species were obtained from other localities.

Further, one would have expected that before he put such a suggestion into print he would have made very sure of his facts; in other words, that he would be prepared to point out exactly where such pockets occur, what species of corals they contain, and how the rock of the pockets differs from the hypothetically older rock in which he says they lie. Dr. Spencer, however, has not done this; all he says on the subject is to be found in the two paragraphs which are quoted below—"I am

[1] Quart. Journ. Geol. Soc., 1895, vol. li, p. 255.

inclined to explain the occurrence of the seven identical species at the higher levels and at Bath, as having been obtained from remnants of the newer formation filling hollows in the eroded surface of the older high-level limestones. This feature may be seen in ascending the western side of the island, where pockets rich in corals form a contrast with the prevailing scarcity of organic remains of the older formation" (p. 359).

"Without entering into the question of what terraces are due to marine erosion, leaving sea-cliffs in the rear of them, and what are constructional from the building up of reefs, it may be said that these deposits of recent coral-species are wide-spread over the surface, not merely below the altitude of 165 feet, but possibly (in part at least) at the higher levels, where pockets of coral-masses containing recent species occur" (p. 362).

It will be noticed that Dr. Spencer contents himself with stating that such pockets exist on the western side of the island; he does not say where, nor at what levels, nor what species of corals they contain. He adduces no evidence to show that the pockets he saw are of widely different age from the surrounding rock.[1]

Further, he does not offer any evidence to prove that the inclined beds in the railway cutting are of the same age as the high-level limestones, nor any evidence that either the former or the latter are of the same age as the rock near the Cathedral which yielded species of *Stylophora* and *Astrocœnia*. Yet he does not hesitate to tell us that these three sets of beds belong to one series, that this series is of Oligocene age, and that it belongs to what he calls the 'Antiguan formation.' We think that further comment on these points is needless.

We next address ourselves to the attempt made by Dr. Spencer to establish an intermediate formation between the rocks which he regards as Oligocene and those which he admits to be Pleistocene. Here, again, his methods are just as unsatisfactory, and are not calculated to inspire confidence in his stratigraphical work.

The beds which he refers to his 'Ragged Point Series' are nowhere stated to be more than eight feet thick, and no fossils are recorded from them, so that he starts by erecting a few scrappy local deposits into a 'series,' without a single fossil to show whether it is of marine or terrestrial origin. He mentions several places where marls containing pebbles of older limestone rest unconformably upon such limestone (our reef-rock), but there is nothing to prove that these marls are marine deposits. They might be Pleistocene rainwash for all the evidence he gives, but we cannot assert them to be such without special examination of them.

We are quite prepared to admit that the mechanical deposit shown in his Fig. 1 must be of later date than the limestone on which it rests, but we cannot accept his dictum that it is older than the reefs which he allows to be Pleistocene. He only mentions one place where he believes such a superposition to be visible; this is near Bath,

[1] A coral-reef is a composite mass of rock, and portions of it are often differently made up and are more fossiliferous than other parts of the same reef.

and of it he writes, "at the foot of the terrace north of Bath . . . . is a horizontal bed of sand containing small rounded pebbles of the harder old calcareous rocks and lumps of the Oceanic Clay. This stratum is succeeded by a coral-formation," which he calls the Bath Reef Series. He gives a diagram of this section showing Pleistocene coral-rock overlying, with apparent conformity, four or five feet of stratified sand which contains pebbles of an older limestone, and he assumes that this sand is of the same age as the mechanical marl of his Fig. 1, though the places are nearly two miles apart and the material of the two deposits is totally different.

Apparently his only reason for correlating these two deposits is that both contain pebbles of an older limestone, and he jumps to the conclusion that these pebbles have been derived from the same set of rocks, for in the legend of his Fig. 2 he describes the calcareous pebbles in the Bath deposit as "rounded pebbles of the White Limestone" (i.e. his Oligocene Antiguan formation). Now this section is known to us, and the limestone pebbles are certainly there, but all those which we obtained were fragments of the yellowish *Globigerina* limestone of the Bissex Hill Beds; many of them contain casts of small cup-shaped corals which are common in the *Globigerina* limestone, but which Prof. Gregory was unable to name.

Dr. Spencer does not mention the Bissex Hill Beds, which were established in 1898 as a separate group of intermediate age between the Oceanic Series and the Coral Reef Series,[1] so that we do not know how he would group them, but the rock is very different from those which he refers to the Oligocene.

It is quite possible that fragments of the older reef-rocks may also occur in the basement-bed of the Bath reef, for that is a low-level reef, only 150 feet above the sea, and may well contain débris from the higher and previously uplifted reefs; but what then? Dr. Spencer's reasoning seems to be as follows:—No. 1 is a mechanical deposit, No. 2 is a mechanical deposit, both occur at about the same level, and both contain pebbles of older limestones; therefore, both are of the same age! We cannot accept such an argument as having any logical value.

From the above remarks it will be seen that Dr. Spencer's evidence completely breaks down: he fails to connect the basement-bed near Bath with his Ragged Point marl; he fails to show that the latter is older than the Pleistocene reefs, or that it is anything but a superficial terrestrial deposit. In point of fact he fails to establish his 'Ragged Point Series' as an independent formation. We are quite aware that there are mechanically formed calcareous deposits of terrestrial origin in many parts of the island, and they have probably been formed at different times during the gradual upheaval of the area, but if Dr. Spencer's methods were followed it would not be difficult to make out five or six 'formations' or 'series' in the later rocks of Barbados or in those of any other raised coral island.

[1] See Messrs. Franks & Harrison, "On the Globigerina Marls of Barbados," in Quart. Journ. Geol. Soc., vol. liv, p. 540.

Finally, we must express our grave doubts about the high dips which Dr. Spencer states that he saw in our Coral Reef Series. One of us resided for ten years in Barbados, traversed it in many directions at various times, and examined nearly every gully in the island as well as most parts of the great limestone escarpment, yet he never saw any such high dips as Dr. Spencer mentions, except where there was reason to suspect a landslip, and such landslips are certainly common. We have noted low dips (of 4° or 5°) at a few places, and some false-bedding which might mislead an inexperienced observer but hardly one of Dr. Spencer's experience. We cannot say that the high dips are always in slipped masses, but we do think that the sloping beds specially mentioned by him near Bath, "upon the flank of the mountain behind" the Bath Reef terrace, are in a mass that has slipped from the great escarpment above.

Let our readers consider also what continuous dips of from 12° to 20° involve; a dip of 15° continued for only one mile on the horizontal will bring in a thickness of 1,367 feet, and even if the surface of the ground fell 300 feet in the direction of the dip, it would leave a thickness of over 1,000 feet, whereas the greatest thickness of combined Bissex Hill Beds and coral-reef limestones proved by Mr. Easton's numerous borings all over the island is only 280 feet.

It will be obvious that the differences between Dr. Spencer and ourselves are so great and so difficult to reconcile that we are not likely to convince one another by argument at a distance from the field of dispute. Fresh observations are required, and above all further collection of fossils must be made, before either party can make any real addition to our knowledge of the geology of Barbados. We have been in communication with Dr. Spencer, and we hope that one of us may be able to meet him in Barbados next March, with the view of discussing the evidence on the spot and of obtaining fossils from the beds which he regards as of Oligocene age. In the meantime we ask our readers to suspend their judgment on the questions raised by Dr. Spencer's paper.

IV.—The Term 'Hemera.'

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

Nearly ten years ago I proposed the term 'hemera.'[1] The term is coming into use; but, so far as I am aware, in the majority of cases it is greatly misunderstood. From this cause arise objections as to its use, such objections being based on the misconception that the hemera is a subdivision of a zone. It is nothing of the kind.

The original description may be quoted. "It is for a palæontological purpose that I propose the term 'hemera.' Its meaning is 'day' or 'time'; and I wish to use it as the chronological indicator of the faunal sequence. Successive 'hemeræ' should mark the smallest

[1] "Bajocian of the Sherborne District": Quart. Journ. Geol. Soc., 1893, vol. xlix, p. 481.

consecutive divisions which the sequence of different species enables us to separate in the maximum developments of strata. . . . . The term 'hemera' is intended to mark the acme of development of one or more species. It is designed as a chronological division, and will not therefore replace the term 'zone' or be a subdivision of it, for that term is strictly a stratigraphical one."[1] "The proposed term 'hemera' is used in a chronological sense as a subdivision of an 'age.'"[2]

These statements should be definite enough. They show that while there were the stratigraphical terms 'zone,' 'stage,' and the chronological term 'age' for the time of a 'stage,' there was no chronological term to denote the time of a 'zone.' So 'hemera' was proposed to supply the deficiency. 'Hemera,' 'age' are the time terms; 'zone,' 'stage' denote the amount of work done in the way of deposition during these times; they are the stratigraphical terms. As I said, a hemera marks the acme of development of one or more species, as a chronological term. Just as a 'day' marks the phenomenon, sunrise, high noon, sunset, or, if one likes to put it so, from sunrise to sunrise again, so a 'hemera' was designed to mark the time from species-rise to species-rise—that is, from the time when one species or set of species becomes dominant to the time when another species or set of species does so. Such time intervals were to be termed 'hemeræ.' And so many 'hemeræ' make an 'age,' just as so many 'days' make a 'week.' However, as 'hemera,' 'age' must be of universal application and always have existed, 'zone,' stage' may be absent locally: either there may have been no strata deposited, or the strata may have been destroyed. At one locality may be seen the strata of the zones A, B, C, representing the work done during the hemeræ A, B, C. At another locality may be observed only the strata of zones A and C. One may rightly say that zone B is absent; but one cannot say that hemera B is absent. Hemera B has been proved as a time-period between hemeræ A and C, by the records at one locality of work accomplished. Therefore, absence of records at another locality cannot show non-existence of time. Time is not local. A man cannot say that there was no Monday in the week because the parish clock happened to be out of order. Yet remarks similar to this, made in regard to hemeræ, are what I have to protest against. "Absence of any hemeræ would not indicate a break in the series of strata" is a sample. A Dorset labourer once came to his master and complained, "Sir, your dawg a bin an yet my fittle." He indicated exactly the agent of destruction. He knew that the deposit (of his dinner) in a particular place had been duly made. He was aware, by facts *subjecta fidelibus oculis*, what agent had been concerned in its removal. And he said so; in effect he said, "There is a break in the series of my dinners due to destruction by a certain agent." But had he employed the language which is used about a hemera he would have said, not "My dinner is gone," but "One o'clock is absent"—"The absence of one o'clock indicates a break in

[1] Op. cit., pp. 481, 482. [2] p. 518.

the series of my dinners." But one o'clock is just what cannot be said to be absent—dinner or no dinner one o'clock must arrive.

So to return to the localities mentioned above: what has to be said with regard to the second is that during hemera B either there was no deposit or there was denudation of a deposit, according as the evidence may warrant.

Since hemera has nothing to do with zone properly speaking, so it has nothing to do with subzone. It has been supposed that hemera is a sort of finer division of a subzone. But it is not. Strictly speaking, there should be just as many zones as there are hemeræ; for the hemera is the time during which a certain piece of work, namely, the deposition of what is called 'the zone,' was done. But it may be said that zones coalesce. I confess to a deal of scepticism about this; for, generally, careful work shows that very attenuated as the deposits may be, yet there are the zones in order of superposition characterized by their distinct faunas. When there is coalescence it is more of the lion and the lamb kind, with the lamb inside: the earlier zone in pieces in the later one. Such is the case in the Radstock district in the Middle Lias, where the *raricostatus* beds occur as pebbles in the *armatus* zone. Here the value of the term 'hemera' is seen. One cannot talk of the *raricostatus* zone at this place, because there is really no such zone; but one can say that the strata deposited during the hemera *raricostati* were broken up and redeposited during the hemera *armati*.

Much of the trouble about zones and hemeræ has arisen from attempts to make the term 'zone' a kind of 'portmanteau word,' one into which several meanings were to be packed. Thus, a 'zone' has been spoken of as a 'zone of life,' as a 'band of deposit,' as a 'portion of geological time.' A 'zone' has even been defined as an "assemblage of organic remains"—which would make the contents of a museum a 'zone.' Now in scientific work we cannot have several meanings packed into one word; and so to take away the portion-of-time idea the term 'hemera' was proposed.

With the life-zone idea there is more trouble. In zoology the zone indicates the horizontal extension of species; it might be required and used in this sense in geology; but the life-zone in geology has reference to the vertical range. Why cannot we call this a *biozone,* using the term to signify the range of organisms in time as indicated by their entombment in the strata? Thus we might have the biozone of a species, of a genus, of a family, or of a larger group. Thus the biozone of the Trilobita would be, say, from Cambrian to Carboniferous; the biozone of Ammonites would be equal to Mesozoic time; the biozone of an Ammonite family, Arietidæ, would about equal the time of the Lower Lias; the biozone of an Ammonite genus, *Coroniceras,* would be through two or three hemeræ; the biozone of Ammonite species would be about equal to a hemera.

Then we are left with zone in its stratigraphical sense, best defined by Mr. J. E. Marr. But we have no business to use it for this, because of the zoological meaning which the term already has.

Now we cannot separate the stratigraphical from the palæontological phenomena; the two go together. Zones are not bands of rock merely, for the strata of a zone may be heterogeneous vertically or horizontally. The zones are really so many entombments of organisms, which entombments are shown to be successive by the way in which they occur in the strata. For these successive entombments as they are exhibited in the strata, why should we not use a term *faunizone*? With distinct terms for the different meanings we shall express ourselves much more clearly.

To return to hemera, I have been asked if it is advisable when faunas differ, and when the index species is absent, to use different names as hemeral designators. I say that it is not advisable. Temp. Edward VII may date an event in Australia as well as in England, even though Edward VII never visits Australia. So hemera *Murchisonæ* will date a deposit in a locality where *Murchisonæ* never resided.

Certainly in historical records each nation has dated its events by the reigns of its own monarchs. Yet it would, in the interests of a universal system, be quite correct, from a chronological point of view, to say that certain events happened in Spain temp. Queen Elizabeth (of England). It is the aim of science to be universal and independent of nationalities. It is the aim of geology to have a universal chronological system, not to apply different and therefore confusing names to contemporaneous periods of time merely because of local faunal differences. And when, as in the Jurassic rocks, the sequence of faunal phenomena from Würtemberg to England can be accurately described by one set of hemeral terms, we may reasonably hope that, as our knowledge increases, if we take the necessary trouble, a universal chronology may be possible. And if that can be done in the Mesozoic rocks how much more may we not expect it in the Palæozoic, seeing that, as Dr. H. Woodward tells us, "the ancient faunas of the earth were far more widespread, more simple, and more uniform than are our recent faunas." [1]

To sum up, a *zone* indicates the horizontal extension of species, and so is a geographical term; a *biozone* is the range of any organism or group of organisms in geological deposits, so it may be said to indicate vertical extension; *faunizones* are, to paraphrase Mr. Marr, "belts of strata, each of which is characterised by an assemblage of organic remains," with this provision, that faunizones are independent of lithic structure—the strata of a faunizone may vary horizontally or vertically, or the strata may not vary and yet may show several successive faunas. So faunizones are the successive faunal facies exhibited in strata. Lastly, *hemera* is a time term—the subdivision of an 'age'; it indicates the period of time from the rise of one dominant species to the rise of the next. It is the time term which corresponds to 'faunizone' as the stratigraphical term, just as 'age' corresponds to 'stage.'

[1] Anniversary Address of the President to the Geological Society, Q.J.G.S., vol. li, p. lxxxvii.

NOTICES OF MEMOIRS, ETC.

I.—The Conditions under which Manganese Dioxide has been deposited in Sedimentary Rocks, as illustrated by the Elgin Sandstones. By William Mackie, M.A., M.D.[1]

MANGANESE dioxide has been observed to occur in the Elgin Sandstones under the following conditions:—(1) In ovoid or rounded spots, from $\frac{1}{2}$ inch to 6 inches in diameter, known to the quarrymen as 'vegetations,' at Newton Quarry, in U.O.R. rocks. From analyses MnO_2 varies from ·18 per cent. to ·262 per cent. (2) In small nodules, about $\frac{1}{4}$ inch in diameter, in Triassic rocks, south-east of Cuttishillock, $MnO_2 = 12·87$ per cent. (3) In punctiform spots around decomposing felspars in sandstone of the Rosebrae division, U.O.R. sandstones = ·0715 per cent. of MnO_2. (4) In small spots or lining minute cavities, and evidently following carbonate of lime in Triassic rocks, at Spynie and Lossiemouth, MnO_2 = ·035 per cent. (5) In veins or lining joints, occasionally parallel to and some distance back from the joint-plane. An example from Bishopmill, U.O.R., gave MnO_2 1·27 per cent. + MnO ·27 per cent. (6) Along the upper surface, and occasionally irregularly diffused through the interbedded clayey bands of the Rosebrae division. (7) Uniformly diffused through the sandstone in the same way as the much more frequently occurring ferric hydroxide; seen at Newton, Millstone, and Cloves quarries in the U.O.R. (8) In some organic remains in the same formation; a scute of *Bothriolepis major* gave MnO 2·33 per cent., of *Psammosteus Taylori* ·83 per cent. (9) As a brown or blackish staining on the casts of organic remains. (10) As illustrative examples are cited fragments of cherty limestone in the local Boulder-clays, with their interstices filled with MnO_2, the carbonate of lime having been totally removed, and a specimen of 'black' sand from under Boulder-clay on the Banffshire coast, MnO_2 6·58 per cent. + MnO ·48 per cent.

Experiments made by allowing a dilute solution of manganese sulphate—thirty grains to the gallon—to drip slowly on various rocks and sandstones showed that common chalk and sandstone containing carbonate of lime were darkened in colour within twelve hours. Sandstones without carbonate of lime were not darkened. If the specimens were first moistened with dilute ammonia, caustic soda or potash, or the carbonated alkalies, darkening to a degree, took place very rapidly. Free ammonia was found to exist in every specimen of sandstone from the area examined, and to be particularly plentiful in Newton sandstone. An acid reaction was obtained in some of the 'black' spots at Newton, due, it was believed, to the oxidation of sulphur, which was also present. Others gave a marked alkaline reaction. The presence of ammonium chloride was also demonstrated in a number of the sandstone specimens. In the presence of ammonia and ammonium chloride, manganese is only precipitated after it is peroxidized, but peroxidization is rapidly effected in the presence of free ammonia or other free alkali.

[1] Read before the British Association, Belfast, Sept. 1902, in Section C (Geology).

Though the solution of ammonia and ammonium chloride in the sandstones is no doubt very dilute, it is probably, as compared with the solution of manganese in the infiltrating water, relatively strong.

Presuming the access of oxygen—which may be taken for granted in the case of porous rocks like sandstones—the explanation of the precipitation of manganese dioxide simply resolves itself into accounting for a preponderance of alkalinity at the special points of precipitation of that substance. Analyses show that the manganese areas contain excess of lime, magnesia, and alkalies, compared with what obtains in the surrounding sandstones. This may have been a cause of increased alkalinity, and hence of the precipitation of the manganese dioxide. On the other hand, it may simply be a concomitant of the precipitation, and due to the same cause. The alkalinity in some of the manifestations enumerated has undoubtedly been due to carbonate of lime, (1), (2), (4), (8), (9); to the ammonia arising from the decomposition of organic remains, (1), (8), (9); to the presence of carbonated alkalies, (3), (5), (6), (7); and to free ammonia of the sandstone water after the total precipitation of the ferric hydroxide in a higher zone of the sandstones, (7). The conditions that are necessary for the precipitation of manganese dioxide are the presence of alkali or alkaline substance in excess, soluble manganese compounds in transit, and facility for oxygenation.

There is nothing particularly unique in the precipitation of manganese dioxide. It is simply an extension or continuation of the same action as determines the precipitation of ferric hydroxide, and a general separation is effected between the two substances by the fact that the iron compounds fall out before the manganese as the infiltrating water containing them encounters further and further supplies of alkali. The general distribution of the two substances in the Elgin Sandstones illustrates this natural method of separation, the rocks impregnated with secondary infiltration of ferric hydroxide in a general way occurring in a zone overlying those impregnated with manganese dioxide.

In the author's opinion the manganese nodules of the deep-sea deposits owe their origin to the operation of the same or similar causes.

As a general summary it may be stated that the principles involved in Weldon's process for the recovery of manganese were long anticipated, and had long been in operation in Nature's processes before Weldon's day.

II.—The so-called 'Fossil' Water of Sedimentary Strata, as illustrated by the Sandstones of the Moray Firth Basin. By William Mackie, M.A., M.D.[1]

A SERIES of determinations of the soluble chlorides and sulphates locked up in the interstices of the Elgin Sandstones, was made to test the thesis that from such an examination it is possible to determine the character, as to freshness or salinity, of the waters of the basin of deposit of a series of sedimentary rocks.

In the present case, though some interesting side issues were no

[1] Read before the British Association, Belfast, Sept. 1902, in Section C (Geology).

doubt made manifest, the results as regards the main issue were found to be entirely negative. In all, 38 determinations were made: 7 in L.O.R. rocks, 17 in U.O.R., 6 in Triassic, 1 in Jurassic, and for the purposes of illustration 7 in recent deposits. The averages obtained were:—

	Cl, per cent.	SO_4, per cent.
L.O.R.	·0101 ...	·0180
U.O.R.	·0077 ...	·0064
Triassic	·0050 ...	·0051
Jurassic	·0037 ...	·0113
Recent	·0049 ...	·0042

Average over all: Cl, ·0063 per cent.; SO_4, ·009 per cent.

Some interest attaches to these averages in relation to the question of the saltness of the sea. They show at least that a fairly large proportion of that saltness may reasonably be referred to the washing out in past times of the chlorides and sulphates from sedimentary rocks.

The increase shown by these averages from the younger to the older formations—or, to put it otherwise, from the overlying to the underlying rocks—may be ascribed to the washing in of the soluble salts from the surface and concentration in the depths; but doubt may be expressed if that covers the whole case.

Remarkable variations were obtained in specimens from the same sandstone, even when collected in the same quarry. These variations were in some cases so extreme as to preclude any general conclusion as to the character of the waters of the basin of deposit. It was also found that the percolation of rain-water may reduce the chlorides to ·0005 per cent. or less, and the sulphates to a like quantity, or even to entire absence. Water passing down joints and fissures, it was also found, tends to wash back the soluble salts and concentrate them at some distance back from the fissures. Chlorides, and less frequently the sulphates, were found to increase in rocks secondarily stained with ferric hydroxide, and also in the manganese areas. It has been shown elsewhere that traces of the heavy metals are disseminated through the Elgin Sandstones generally, and also tend to increase in relative proportion in the manganese areas. Increases in lime, magnesia, and alkali have also been demonstrated as obtaining in the same areas. From the intimate relationship of all these substances it is inferred, with some degree of certainty, that they formed part of the same general infiltration. If so, it must also be inferred at the same time that the original 'fossil' water of these sandstones must have long ago been washed out, or at least seriously masked in the process. Generally it may be said that such washing out of the original 'fossil' water may have taken place anywhere, and that the result of subsequent infiltrations may have themselves been replaced again and again by other infiltrations, and so on. The inference, therefore, that the soluble salts of a series of deposits represent the salts of the original waters of the basin of deposit must in the majority of instances be a very uncertain one, if indeed any degree of certainty can be claimed for such an inference under any circumstances.

III.—Short Notices.

1.—A Backward Step in Palæobotany. By G. F. Matthew, LL.D. Trans. Roy. Soc. Canada, ser. ii, vol. vii, sec. iv, p. 113.

Some years ago the late Sir Wm. J. Dawson described a fine collection of fossil plants from a locality near St. John, and on the evidence which he obtained from them stated their age to be Devonian.

Lately, other palæobotanists, Messrs. R. Kidston and David White, reviewing this evidence, have come to the conclusion that these plants must belong to the Coal-measures. The present article is written in support of the original view that these 'plant beds' and their flora are much older.

Evidence is deduced from the stratigraphy that several eroded terranes lie between the true Coal-measures and the 'plant beds,' and that these must be much older than the former.

The composition of the flora is also examined, and it is shown that this series contains a number of genera of plants not found in the Coal-measures proper, and that while a small percentage only of the species of the plant beds are identical with those of the Coal-measures of Pennsylvania, about half of these are found in the European Coal-measures. The connection of the plant beds with the Coal-measures, therefore, seems a distant one.

2. Royal Society's Catalogue of Scientific Papers.—The Royal Society has issued a circular appealing for funds to enable it to carry out the original scheme of cataloguing the papers contained in scientific periodicals up to and including 1900, of which twelve quarto volumes have already been issued, and the work brought down to 1883. The Society has already spent £14,790 5*s.* 5*d.* upon the matter, and now thinks that it might receive a little more financial assistance from others, especially as its expenditure has increased considerably of late years in other directions. They want £12,000, and it should not be difficult to raise the amount. The Society also proposes to issue a subject index for the whole period of 1800–1900, an index which, if properly done, should be of enormous value. It is pleasant to note that both these works are already in hand, and the completion of the author catalogue may be expected in about five years. Dr. Ludwig Mond, who previously gave £2,000, has headed the new list of subscriptions with the magnificent donation of £6,000, and Mr. Carnegie has contributed £1,000. We hope the delicate shade of meaning given to the letters F.R.S. by an eminent expert will be borne in mind by others who have found it an equally valuable asset.

3. North German Lower Cretaceous.—Dr. A. von Koenen has given a revised classification of the Albien in the Nachricht K. Gesell. Wiss. Göttingen (Math.-Phys.), 1901. This includes the Aptien, Barrêmien, Hauterivien, and Valanginien, each of which he divides into upper and lower. In the copy of his paper before us, a separate from the author, we note that he has corrected his

lower Barrêmian by placing the zone of *Crioceras elegans* above instead of below the zone of *Ancyloceras crassum* and *Crioceras fissicostatum.*

4. Chalk Foraminifera.—The foraminifera of the *Inoceramus*-beds of the district of Rzeszow and Debica have been figured and described by W. Friedberg in Bull. Intern. Acad. Sci. Cracovie (Dec. 1901). Out of 92 forms mentioned some 66 were previously found by Grzybowski in the *Inoceramus*-beds of Gorlice (ibid., April, 1901). The figures given by Friedberg are rather rough and unsatisfactory.

5. Patagonian Tertiary Mollusca.—H. von Ihering has an important though short paper on this subject in the Proc. American Phil. Soc., xli (April, 1902). He states that Borchert erroneously determined many of the forms, and thus was led to a wrong idea as to the age of the beds. Ihering regards the Parana formation as Miocene, and the Cape Fairweather beds as the representative of the Pliocene of Argentina in the south, while the same formation in the north is seen in the Tehuelche beds. The 'Pampeano superior' of Ameghino he regards as Pleistocene, and the *Pyrotherium*-beds as Eocene. Ihering says that there are neither existing nor Mesozoic species of mollusca in the *Pyrotherium*-beds.

6. Oligocene and Miocene Deposits of the Great Plains.—Hatcher, in the same Proceedings, discusses the origin of these beds, dealing with the character of the materials and the palæontological evidence. He arranges the White River formation thus: 1, *Titanotherium*-beds; 2, *Oreodon*-beds; 3, *Leptauchenia*-beds. The Loup Fork formation thus: 1, Gering Sandstone; 2, Ogalalla formation. The Arikaree formation thus: 1, Monroe Creek beds; 2, Harrison beds; 3, Nebraska beds of Scott. All from below upwards.

7. The Hull Museum.—Although this museum has been opened but a few months, Mr. Sheppard has already got into excellent shape the collections of Antiquities and Animals. He is now at work upon the geological material. Among this is the collection made by F. A. Bedwell (afterwards Judge) from the Chalk. Bedwell was the author of the paper on the Ammonite Zone of Thanet, which appeared in the Geologists' Association Proceedings, a paper the accuracy of which has been vouched for by Rowe. When Mr. Sheppard has cleaned and arranged this Chalk collection, which no doubt all came from the South of England, he will probably find some interesting specimens, and possibly some types.

8. Geology of Hertfordshire.—Mr. Hopkinson has issued in the Trans. Herts Nat. Hist. Soc., 1902, vol. xi (3), a list of works on the geology of the county from 1884 to 1900. This is in continuation of a previous list, and that again of Whitaker's list of 1875. We wish other county societies would see their way to publish similar lists regularly. A few have done so, but it is not general, and the matter might well engage the attention of the British Association Committee.

9. PRE-RHÆTIC DENUDATION OF THE BRISTOL AREA.—Dr. Callaway deals with this subject in the Proc. Cotteswold Nat. Field Club, 1901, xiv (1). The paper gives a clear sketch of the country before and after Rhætic times, and is illustrated by two sections, one of the Avon section and the other of the Avon gorge.

10. MANCHESTER MUSEUM.—Mr. Hoyle's Annual Report for 1901–2 is highly satisfactory. The Rev. Arthur Dixon has given the museum a fine collection of fossils, rocks, and minerals. Other geological material acquired by gift or purchase is a series of rocks from Charnwood Forest, sections of coal plants selected to fill gaps in the collection, collection of magnesian concretions, of stalagmites and stalactites, Permian rocks from the Lakes and Isle of Man, and cores from borings in the Isle of Man.

REVIEWS.

I.—GEOLOGICAL SURVEY OF ENGLAND AND WALES. Sheet 123 (Stoke-on-Trent). Solid and Drift Editions. Scale, 1 inch to a mile. (Price 1*s.* 6*d.*)

MEMOIRS OF THE GEOLOGICAL SURVEY OF ENGLAND AND WALES. THE GEOLOGY OF THE COUNTRY AROUND STOKE-ON-TRENT (Explanation of Sheet 123). By WALCOT GIBSON, B.Sc., F.G.S., and C. B. WEDD, B.A., F.G.S.; with Notes by GEORGE BARROW, F.G.S. (1902. Price 1*s.* 6*d.*)

IT is necessary to discuss the Map and Memoir as separate items, because so much of the technicalities of the production of the map is new and important. It is incidentally stated in the preface to the Memoir that "Both maps are colour-printed, and they represent the first attempt to substitute colour-printing for hand-colouring in the issue of the 1 in. Survey maps." We must heartily congratulate those who originated the idea and those who have so ably carried it out, for the result is highly praiseworthy, and may be considered as a triumph of geological map printing. The map will be, at any rate, free from the personal errors of the colourist, and the colours will be both more permanent and will always agree with the colour index in the margin. This improvement, however, carries with it a great reduction in price, the sheet being issued at 1*s.* 6*d.* per copy instead of 3*s.*; and, by the way, the old quarter-sheet at 3*s.* only measured 13½ by 10 inches, while the new sheet is 18 by 12 inches. The new sheet covers a somewhat different area, taking in more ground to the west, and not including area to the east which appeared on the old sheet. We hope that the new issue of cheap, accurate lithographed geological maps will henceforth replace the hand-coloured editions.

The mapping is much more detailed. The four divisions of the Upper Coal-measures are shown by distinct colours, with, in addition, brighter colours for particular beds, such as limestones and a green grit. We quite agree with the wisdom of making no distinction between Middle and Lower Coal-measures, and rejoice to see that the shales and grits belonging to the Pendleside Series are classed with the Millstone Grit. Thus the new map indicates the absence of rocks of the true Yoredale type and the Permian series in the Stoke-on-Trent area. A dolerite dyke intrusive in Upper Coal-measures, and Bunter Pebble-beds, are mapped for the first time. The maps, both drift and solid, are accurate and full of detail, and we congratulate Mr. W. Gibson and his colleagues on the result of their work. In my copy of the solid map there is one small error of colour which does not appear on the drift edition: the lower part of the band representing Upper Coal-measure limestone south of Chesterton is coloured bright blue, instead of being the same tint as the patch a little to the north.

The Memoir (pp. 1–87, with several diagrammatic illustrations) might be included as a heading for the new section. It appears to us to be carefully and thoughtfully written, sufficient as an explanation of the map, and accurate in detail, the worst faults being probably printer's errors. Due thanks are given for all the local help received, and it has not been of small amount. Owners and engineers of mines have generously placed their plans and sections, and journals of borings, in the most unselfish way in the hands of the Survey, and local geologists have received the compliment of having many of their very radical views adopted, after a most careful review of the evidence in the field.

We note the absence of Permian and Yoredale beds from the table of strata; instead of the Permian Mr. W. Gibson gives his carefully worked out sequence of the Upper Coal-measures of North Staffordshire, and we read in the preface that "The Pottery Coalfield presents a type development of the Midland coalfields, to which the sequence in other districts can be referred."

Chapter ii, on the Millstone Grits and the beds below, by Mr. G. Barrow, F.G.S., is headed by an instructive section of the rocks across Endon. He remarks on the peculiar character of the black shales below the Crowstones and the Stanley Grit. "The dark shales contain a great number of small plant-remains, the mode of occurrence of which is suggestive of leaves falling into comparatively smooth or quiet waters. They further suggest the idea that much of the shale may be due to a process of filtration of coarser material by dense vegetation, which arrested the flow of the heavier sand particles, and at the same time supplied the great number of comparatively uninjured fragments of plants." This idea is full of suggestion, but it connotes the nearness of land, and these beds thin out very rapidly to the south and west. We note one fault, almost characteristic of Survey Memoirs, in this chapter. Mr. Barrow is quite contented with the generic names of his fossils, but we wish he had recognized the great importance of adding the species also. *Goniatites* and *Aviculopecten* convey very little accurate knowledge of horizons. The single important fact, however, comes out, that the shales between the grits and crowstones contain marine fossils as a rule. We miss, too, the list of plants found when driving through the shales between the first and third grits at Stockton

Brook Waterworks, identified by Mr. R. Kidston, and published in the Transactions of the North Staffordshire Field Club for 1889.

Chapter iii deals with the Lower and Middle Coal-measures: an artificial horizon, the Ash Coal, is taken as the base of the Middle Coal-measures. We ourselves should have felt inclined in the first place to make no subdivision, or to have placed it at the horizon of the 7 foot Banbury seam. Mr. Gibson seems doubtful of the utility of this subdivision, and it is difficult to see what good purpose it serves. He has wisely not given different colours to the two divisions on the map.

The lowest part of the coalfield, below the Winpenny Coal, is not well known, and none of the coals are now worked. The measures are about 1,200 feet thick. *Carbonicola acuta*, *Lingula Credneri*? occur in them at different horizons, as well as the marine fossils indicated. A note at the bottom of p. 19 informs us that the section marked with an asterisk is by Mr. Barrow. The asterisk has been omitted, but presumably the article on the Shaffalong Coalfield is referred to. The important seam in the Cheadle Coalfield known as the Froghall ironstone, a hæmatite which lies on or a few feet above the first grit in the neighbouring Cheadle Coal basin, has not been proved to be present either in the Shaffalong or Biddulph Valley basins.

It is pointed out that throughout the Coal-measures in North Staffordshire the measures between the coal-seams thin out rapidly to the west and thicken to the north. It is a well-known fact, and the Millstone Grit and Pendleside Series also thicken rapidly to the north and north-east, indicating the direction of the land whence the detrital matter was obtained. In connection with this subject we are informed (p. 25): "On comparing the shaft sections in this area [Biddulph] with those in the Longton district it will be noticed that there is a larger proportion of sandy material in the northern area." Naturally sand grains, being heavier, would not be transported so far as the lighter shale particles.

The nodules with marine fossils over the 7 foot Banbury seam at Lycett Colliery are strongly suggestive of the fauna and general character of the roof of the Bullion coal of Lancashire. The different character of the coals as regards cokeing (spelled 'cooking,' line 16, p. 32) is of interest, those on the east side of the coalfield not having this quality, but the same seams on the west cokeing well.

Chapter iv deals with the Upper Coal-measures, and is well worth study. Mr. Gibson has previously indicated the main features of his discoveries and views on this important series of rocks. It is not therefore necessary to give his table here in detail. It suffices to say that there are four well-marked subdivisions, which he names the Keele Series, 700 feet; Newcastle-under-Lyme Series, 300 feet; the Etruria Marls, 800 to 1,100 feet; the Blackband Series, 300 to 450 feet; of which the last is of economic importance, as it contains several valuable Blackband ironstones resting on coals which are worked together, although on p. 17, line 19, it is stated that the Upper Coal-measures contain no workable seams of coal. It is of great interest to know that the same succession is found in the South Staffordshire, Nottinghamshire, and Denbighshire Coalfields.

A suggestive sentence on p. 37 raises the question whether the Radstock Coal-measures of the Bristol Coalfield, which Mr. Kidston believes to be still higher in the series, should come on above the Keele Series. Mr. Kidston's palæobotanical researches led him to suggest that the flora of the Upper Coal-measures of North Staffordshire are transitional between the Middle Coal-measures and the Radstock Beds. We cannot altogether accept this view as conclusive, because *Carbonicola aquilina*, a shell which does not, as far as we know, exist above the Ash Coal, is found in the plant beds of Radstock, and either the plants or the Lamellibranch therefore cannot be of such zonal importance as each specialist would suppose. Up to date, we believe, the Radstock fauna has not been found out of the Bristol area in England or Scotland.

We are informed that a larger Memoir on the North Staffordshire Coalfield is in preparation, and we await this with pleasure if the present memoir be an earnest of things to come.

In the larger memoir we hope for an account of the peculiar limestones of the Upper Coal-measures, and some discussion of their methods of deposition and source. The inconstant character of the Blackband ironstones over the whole area points to the probability that they are of secondary origin, iron having replaced calcium in a limestone, for which view there is certain positive evidence.

The Etruria Marls are largely used for brick and tile making. The green grit contained in them, composed of volcanic material, also stated to occur in other areas at the same horizon, raises an interesting question of whence it was derived, which we hope will be settled in the fuller work on the district. We are glad to note that the red colour of the Etruria Marls is shown to be original; we have always held that opinion.

To the fossils are given two pages, but we are promised better things, and the district deserves it. The long and careful work done by Mr. John Ward and others has resulted in a more accurate and detailed knowledge of the palæontology of the North Staffordshire Coalfield than of any other.

Some few specific names might have been added without difficulty, but we cannot conceive why *Carbonicola lateralis*, a synonym of *C. aquilina*, is quoted as the only species of this important genus worthy of mention.

Chapter v deals with the Triassic beds, which overlie the edges of the Pottery Coalfield with marked unconformity. The following passage shows that the author had a mental horizon not strictly limited by mere map-making (p. 52, l. 12):—"In Triassic times land had evidently obtained the upper hand. The wind-blown and false-bedded sandstones of the Bunter period are a sure index of desert conditions, while the beds of salt and gypsum of the Keuper indicate land-locked sheets of water undergoing rapid evaporation. It is difficult to account for the shingle beds, but it should be remembered that coarse gravels form no inconsiderable portion of the deposits in the Sahara." We welcome these highly suggestive ideas on speculative problems of geology, several examples of which are scattered through the memoir.

Chapter vi treats of faults, folds, and igneous intrusions, and chapter vii of glacial deposits, which are fairly extensive. Their importance may be judged from the following passage (p. 67, l. 17): "The Trent between Abbey Villas and the railway bridge to the north flows in a shallow cutting, the surface of the water being between 390 and 400 feet above O.D., or at a higher level than the pre-glacial surface at the Hanley and Bucknall Collieries." Here the drift is 81 feet thick, making the pre-glacial surface 366 feet above O.D.

The chapter on the "Economic Resources and Applied Geology" is not the least important, but the section on the future of the Coalfield is pregnant with interest. It is gratifying to know that a rich field of coal still exists in North Staffordshire, although at great depths. The Newstead boring, the journal of which is generously made public by those for whom it was put down, shows that the uppermost seam of the Middle Coal-measures was reached at 1,946 ft. 7 in., from which it may be assumed that the Moss coal is 3,400 feet and the Cockshead 4,800 feet, and between these two seams are all the best coal-seams and many ironstones. It is therefore only a question of engineering to win them on remunerative terms.

We feel that this memoir merits unstinted praise, and it will be valued by local geologists and mining men for its accurate details and its thoughtful suggestions. W. HIND.

II.—SUPPLEMENT TO THE ENCYCLOPÆDIA BRITANNICA.

THE ENCYCLOPÆDIA BRITANNICA, SUPPLEMENT, is a work which professes to supply the public with the very latest information on those subjects of which it treats, and naturally excites the curiosity of the man of science. And with this in view we have asked some of our younger contributors to give our readers a few ideas on the articles dealing with geological and palæontological matters in the Supplemental volumes of the Encyclopædia Britannica, six of which have been issued in the last few months.

ARACHNIDA, by E. Ray Lankester. More like a book than an article, though one does not grumble at abundance of information. A review of the group, and of considerable importance to geologists, though there is nothing absolutely new palæontologically in the article.

GEOLOGY, by Sir Archibald Geikie. Compared with the last article is very scrappy considering the importance of the subject. Has a paragraph on zonal stratigraphy. Very curious. Still more curious is the careful reference to Professor Lapworth's work on the zones of the Silurian and Ordovician, and the absolute silence concerning the more recent work on similar lines by Wheelton Hind on the Carboniferous Limestone, by Buckman on the Inferior Oolite, and by Dr. Rowe on the White Chalk.

Ichthyology, by Albert Gunther. In this article much more attention has been paid to fossil fishes than in the article in the earlier volume. Still, in a publication intended to afford the latest information on the subject more might have been gathered from the recent work of palæichthyologists. The classification given is open to modification and does not seem in accordance with modern views.

Birds, by H. Gadow. A valuable article, which discusses the various classifications, and terminates as usual in a new classification of the author's own. Gives a summary of recent work in palæo-zoology, and emphasizes the futility of attempting to derive birds from the Pterosauria, as equal to that of attempting to derive them from the Dinosauria.

Cuttle-fish, by J. F. Blake. Writing on Cuttle-fish, Mr. Blake contrives to run the gamut of all the Cephalopoda, apparently with the object of explaining to the ignorant what is the exact relation of *Sepia officinalis* to the rest of the universe. Incidentally he coquettes dangerously with Steinmann's speculation that the Octopoda are the descendants of the Ammonites, a view which, if ever accepted by anyone beyond its author, has surely been disproved by the subsequent observations of Appellöf. It is also remarkable that the author of this article in the Encyclopædia Britannica should not yet have satisfied himself as to the homologies of the cuttle-bone.

Earth, Figure of. Mr. R. Radau, of Paris, writing nominally on "The Figure of the Earth," gives an account of past and future (chiefly future) expeditions to measure arcs. He prefers the ellipsoid of revolution as the spheroid of reference, but says little as to the manner or extent of difference therefrom displayed by the geoid, and says nothing about the tetrahedral theory so much boomed of late.

Coal, by H. Bauerman. Chiefly concerns mining. A sketch of the origin of coal is given, but the reader had better consult Seward's papers in "Science Progress," 1894, and his "Fossil Plants," 1898.

Alps, by T. G. Bonney. Commences with a tribute to the excellence of the article on Alps in the Encyclopædia itself. Then plunges into a brilliant survey of the whole subject. The bibliography includes Dr. Heim.

Brachiopoda, by A. E. Shipley. Mr. Shipley treats Brachiopoda chiefly from the standpoint of the anatomist, and gives a useful summary of the work of Blochmann and others. He does, however, discuss the aperture for the peduncle, and the classification based on the various modes of its closure. "What is a Brachiopod?" is an old question. Mr. Shipley is not to be caught. They are an "isolated group"; yet they "seem to belong to that class of animals which commences life as a larva with three segments"; but, lest this should be too warm a scent, he adds that "trisegmented larvæ have been found now in several of the larger groups."

Earthquakes, by J. Milne. Who should write on Earthquakes if not John Milne? Right valiantly does he urge the claims of the tremulous science, giving a history of seismometry, with figures of all manner of seismometers, and showing the value of seismology in every department of human activity. Geologists will note with interest that he finds no direct connection between earthquakes worthy of the name and volcanic eruptions, but rather looks on them as a symptom of rock-folding: when a rock-bed snaps under the strain we feel the vibrating shocks, but when masses are displaced the quake undulates around the earth.

Glaciers. There is no article on Glaciers. Perhaps the editors are awaiting the return of the "Discovery."

Fens, by J. T. Bealby. Too short, but a capital little sketch. Might have given a little more about the geological history of the area.

Amphibia, by G. A. Boulenger. An up-to-date article, giving a very condensed survey of the subject, including all recent work. Excellent bibliography.

Channel Tunnel, by W. B. Dawkins. Useful sketch of the history of the work and its geological interest. Mention of Francis Brady's detailed section of the boring for coal at the same spot on the English coast, printed in 1892, would not have been out of place in this article.

Echinodermata, by F. A. Bather. Considering the numbers and variety of the Echinoderms, and the enormous amount of work done on them since the rather inadequate article in the ninth edition of the Encyclopædia, we are not surprised that Dr. Bather has found it impossible within seven pages to give more than a sketch of modern views as to the morphology of the group. He has devoted himself to making clear the relations of the Echinoderma to the other phyla of the Animal Kingdom, and the supposed origins and interrelations of the various classes; but into any account of these latter he declines to be drawn, considering, no doubt, that each of them should have an article to itself.

III.—Bibliography and Catalogue of the Fossil Vertebrata of North America. By Oliver Perry Hay. Bull. U.S. Geol. Surv., No. 179. 8vo. (Washington, 1902.)

Anyone who will take the trouble to cast his eye over the series of volumes which form the Bulletins of the United States Geological Survey cannot fail to be filled with admiration at the mass of digested information presented for his use, and amazement that so much bibliographic work can have been turned out in so short a period. And yet these 180 volumes (1883–1902) form only a small part of the publications of the United States Geological Survey, which is supported by the State in a manner so magnificent that it compels our envy. Not only are they models of what such publications should be, but they embrace so wide an interpretation of the word 'geology' that scarcely any subject, however remote its connection with the science, but finds a place in its volumes. Moreover, the volumes themselves are distributed with so lavish a hand that any student can obtain them either for the asking or else for a sum so insignificant as to be afforded by the poorest.

As an instance of the range of subjects we may mention the following, all of which have formed bibliographies or books of reference of the most comprehensive and valuable nature:—

Scudder: Index to known Fossil Insects of the World.
Marcou: Catalogue of Geological Maps of America (1752–1881).
Vogdes: Bibliography of Palæozoic Crustacea.
The series of Correlation Papers.
Records of North American Geology since 1886.
The series of Gazetteers of the States. In progress.
Darton: Catalogue and Index to North American Geology, 1732–1891; continued by Weeks, 1892–1900.
Branner: Bibliography of Clays, etc.
Knowlton: Cretaceous and Tertiary Plants.
Weller: Index of North American Carboniferous Invertebrates.
Schuchert: American Fossil Brachiopoda.
Gannett: Dictionary of Altitudes in the United States.
Warman: Catalogue and Index to the Publications of the U.S. Geol. Surv.

The one before us is not the least of these invaluable books, and it is a pleasure to offer to Mr. O. P. Hay hearty and sincere thanks for a book which has long been wanted, and which will certainly be of the greatest value to British zoologists. Mr. Hay divides his book into a Bibliography (up to 1900); a tabular Key to the catalogue; a Catalogue (of the genera and species); Addenda et Corrigenda; Index. The whole book runs to 868 pages. The synonymy is compressed into a minimum of space, by an arrangement of quotation by which the several papers are referred to by year and page only, the reader having to refer to the Bibliography for the full quotation. This, though a loss of time to the user, seems inevitable now that the subjects have grown to such vast dimensions. The Index is arranged under trivial names, each followed by its generic variant, and thus any specific name can be found without trouble.

To criticize such a work as Mr. Hay's would not be possible without great trouble; use only can show whether his work is accurate. However that may be, we have to thank him for his labours, labours rarely fully appreciated by those who find in such books almost half of their own work done for them. C. D. S.

IV.—Harlyn Bay and the Discoveries of its Prehistoric Remains. By R. Ashington Bullen, B.A., F.L.S., F.G.S., etc. Second Edition, revised and greatly enlarged. 8vo; 96 pages, with 18 plates and 9 text-figures. (London: Sonnenschein & Co., 1902. Price 1s.)

THE truthful records of any people lead us to consider the land in which they dwelt, and especially its surface accumulations, retaining evidences of early human occupation. These may be ornaments, utensils, tools, or weapons; relics of the life-abodes or skeletal remains. Thus archæology and geology have met in the study of very many interesting exposures of archaic remains; and now attention is directed to Harlyn Bay, near Padstow, in Cornwall. Here a prehistoric grave-ground and a recognizable hut near by form an interesting picture of long past times, framed on one side with the great Palæozoic crags of the Bay, on the other hand passing into the wide Atlantic with its mysteries of sunken lands and lost Atlantis.

The details have been preserved by the thick coating of shore-sand derived in ages past, partly from broken sea-shells and partly by sea and wind from rocks and strata no longer visible.

The neighbouring country is characterized by the tumuli and flint weapons of people of the later Stone-age. But on the shore of the Bay, in making foundations for a new house, there were found beneath 15 feet of sand at least a hundred slab-made cists or stone graves, with bones of the ancient people, accompanied by many flakes of the hardest slate of the vicinity. These bits of slate had been deftly trimmed into pointed and sharp-edged knives, besides awls, scrapers, hammers, etc. Some are shown in plates iv, v, and vi. The use of slate for tools and utensils is illustrated with reference to other observers abroad and at home. Some small flint flakes and tools from near Harlyn are shown in plate vii.

The slabs of slate and flagstones largely used for the sides, ends, and covers of the cists were obtained from the rocks near by (known as 'Devonian' in systematic geology). In some cases blocks of stone had evidently been dropped directly on the head of the dead or dying persons laid in the graves. In some graves the whole skeleton had been intentionally flattened by the fall of the upper slab. Mr. Bullen has carefully quoted the descriptions given by some authors of such maltreatment of the dead or dying occupants of new graves; also as to the occasional custom of separated limbs being arranged in burial; and indeed, further, he has to allude to the sacrificial imbedding of a living victim, for he has noticed evidently a more or less analogous case under some of the old stonework. Thus there are here subjects of study for the archæologist in the graves, and for the geologist in the surroundings. This little book, with its numerous plates and figures, abundantly proves this; and the author's particularly careful collateral allusions to analogous customs among various ancient and archaic people give much interest and instruction to the reader.

REPORTS AND PROCEEDINGS.

Royal Society of New South Wales.

(From the Abstract of Proceedings, September 3rd, 1902.)

Professor Warren, M. Inst. C.E., etc., President, in the Chair.

Among others, the following paper was read: "Meteoric Dusts, New South Wales," by Professor Liversidge, M.A., LL.D., F.R.S.

The term meteoric dust is used because it is commonly applied to the materials forming the subject of this paper; it is not intended to state that the dusts are necessarily of cosmic or extra-terrestrial origin. The specimens described and exhibited were from Moruya (fell on Dec. 15th, 1880), from Uralla (fell on Dec. 14th, 1882), from near Broken Hill (fell 1896), from Menindie (fell June 17th, 1899), and Pambula (fell Oct. 5th, 1899). Dust from the roof-beams and mud from a covered cistern at the University and from the roof of the Observatory, Sydney, all three were collected in 1882. All the dusts are of a reddish colour except those from the University and Observatory, which are grey. The red dusts are mainly silicious and argillaceous, and look as if they had come from dried-up water-holes; they contain a variety of organic and mineral matters such as might be expected from such a source, and in addition magnetite and metallic iron; the latter contains cobalt and nickel, which seems to indicate that the dusts contain some cosmic or extra-terrestrial materials, part of which may have settled down and become mingled with the undoubted superficial terrestrial deposits and part may have been derived directly from the atmosphere. The University and Observatory dusts also yielded magnetite and metallic iron containing cobalt and nickel, and the University dust yielded particles of gold; the Observatory dust has yet to be tested. The Moruya, Menindie, and Barrier red dusts yielded particles of gold; the others have yet to be examined. Fuller information is given in the paper as to the constituents and chemical composition of the dusts, and analyses of volcanic and other dusts for comparison.

Professor Liversidge also exhibited under the microscope particles of a malleable yellow metal, which have all the appearance of gold, obtained from certain Australian and European meteorites (siderolites). The presence of gold in meteorites bears upon the presence of gold in 'meteoric' dusts, and it is also of great interest in connection with the presence of gold upon the earth and in sea-water, inasmuch as meteorites and the dust of meteorites are constantly falling upon the earth to the extent of probably many million tons a year. Further information upon the question of the presence of gold in meteorites will be given shortly in a subsequent paper.

CORRESPONDENCE.

HYDROTHERMAL METAMORPHISM.

Sir,—I crave a few words of explanation of my paper on Hydrothermal Metamorphism noticed in your current number. The ulterior object of the paper was to elicit a discussion on the singular fact that in the Devon schists albite containing fluid inclusions is intimately associated with chlorite and other water-bearing minerals; and this in rocks which show no sign of any high temperature, far less of fusion. So far as I am aware, albite has only been produced artificially in the crucible at a high temperature. After my little paper was written I found to my dismay that it would appear to intrude on the subject of the President's Address, and on hearing the address I found that the President actually discussed the fusion temperature of albite from one extreme, whereas I had hoped to coax a discussion on the other extreme. Thus, instead of being able to ask the opinion of the section, I was obliged with all emphasis to warn the section not to allow my paper to be an excuse for discussing the President's views, and so transgress the inviolable custom of the British Association, not to attack a chairman when he is not free to defend himself. My paper being sent in too late for me to supply an abstract, the Recorder of Section C most kindly wrote the excellent epitome you have published, and therein stereotyped an undoubted ambiguity which I subsequently corrected in reading. Of course, hornblende does not always contain water, as might be inferred from my manuscript; but certain varieties are said to do so. But in the event of the hornblende being rejected, the chlorite, epidote, zoisite, and the fluid inclusions in the albite, are sufficient to prove my point. A. R. Hunt.

Foxworthy, Moretonhampstead.

'SONOROUS' SAND.

Sir,—In September last I paid a visit to Tenby, and while there made a point of seeing the notable junction between the Old Red and Carboniferous series of rocks. The section is met with a few miles to the west of Tenby, in a small bay called Skrinkle Haven. I was doubly repaid for the effort of getting to this not very accessible spot by seeing a most interesting geological section, and finding musical notes emitted from some of the sand traversed while examining the junction.

I had never met with the phenomenon before, and, being preoccupied, at first attributed the sounds to a knocking together of articles on my person; but, giving my attention to it, found the sounds arose from my feet at each step, as my boots sank into the sand. The notes were clear and metallic, and were emitted only from the dry, loose sand above the range of the tide. I did not test its 'musical' property in any other way than walking in it, but found an increase in the sound on thrusting the heel deeper into the sand.

In *Nature*, vol. xxxix, there are references made to investigations and explanations in regard to these sounds. Dr. Julian and Professor Bolton attribute them to "a film of condensed air round each grain of sand, which acts as an elastic cushion, and enables the sand to vibrate when disturbed," while Mr. C. Carus Wilson considers the sound to be caused by friction, "the cumulative effect of numerous vibrating particles that becomes audible."

In accordance with Mr. Wilson's theory, the grains in the patch of sand which emitted the sounds "were rounded, polished, and free from fine fragments; they must have had sufficient amount of 'play' to enable them to slide one against the other; the grains were perfectly clean, and possessed a certain degree of uniformity, within a certain range of size" (vide *Nature*, vol. xliv, p. 322).

A number of places where such sand is met with is given by these writers and others, but as no mention, as far as I am aware, is made of Skrinkle Haven, I thought it might be of sufficient interest to justify this note. HARFORD J. LOWE, F.G.S.

TORQUAY.

SOUTH AFRICAN PETROGRAPHY.

SIR,—In my paper on the above subject in the August number I should like to point out two errors. Fig. 4 represents the diorite described immediately above it, and not, as stated, the granite referred to on p. 364. The other error, for which I am myself responsible, is in a reference to the melilite-bearing rock of the Spiegel River in Cape Colony (p. 366). This was discovered by Messrs. Rogers & Schwarz, of the Cape Geological Commission, and described by them in the report of that body for 1898, p. 62. Professor Cohen's description referred to is of a Transvaal rock of a similar character, and I cannot now account for having confused it with the other. My delay in correcting this slip is due to absence up country, during which I received no papers. F. P. MENNELL.

RHODESIA MUSEUM, BULAWAYO, 1902.

THE CRUMLIN METEORITE.

SIR,—In your issue for November, p. 521, you remark in regard to the meteoric stone that fell at Crumlin on September 13th, that "no one [in Ireland] thought it worth while to investigate what appeared to be a hoax." May I state, as I have already done in the *Irish Times*, that the first newspaper notice of the event appeared in the *Northern Whig* for Sept. 17th, when I was crossing to Scotland. This contained so clear an account that I never suspected the fall to be other than genuine, and at once commenced negotiations on behalf of the Museum in Dublin. Mr. Walker, the owner of the stone, although at the time unwell, replied promptly; but I was by then travelling in Scotland, and his letter was forwarded to me to an incorrect address. Consequently, I received it only on October 29th, and had heard long before that the stone had been, very naturally, secured for the British Museum. GRENVILLE A. J. COLE.

DUBLIN, *Nov. 3rd*, 1902.

FOSSILS OF THE OXFORD IRON-SANDS.

SIR,—As the fresh-water fossils of the Oxford Iron-sands are now so difficult to obtain, it is worth noting that during a traverse of the Lower Cretaceous outcrop which I made in June last I chanced to find a place where these fossils can be obtained in abundance, though not from rock actually *in sitû*. The locality is Combe Wood, about half a mile south of Wheatley Station and five miles E.S.E. of Oxford. A low stone wall on the western side of the high road which flanks this wood on the west is in places built of thin, flaggy iron-grit crowded with the casts of *Unio, Cyrena, Paludina,* etc. The stone for this old wall must have been obtained in the immediate vicinity, probably from a small pit now overgrown and concealed in the adjacent woodland. I found afterwards that most of the Iron-sand fossils preserved in the Geological Survey Museum at Jermyn Street, collected many years ago, are labelled "Combe Wood," and are in all respects like those which I obtained from the wall; they were probably got when the quarry was open. This flaggy iron-grit may possibly form part of the supposed Purbeck deposit of Combe Wood described by Fitton and mentioned by Professor Phillips, though more probably it has been obtained from the sands just above that horizon.

I was able to devote only a very short time to the examination of the material, but noticed that the fauna, though rich in individuals, was scanty in species. A more thorough investigation is, however, highly desirable, especially as the relation of this fresh-water fauna to the marine Lower Greensand stands in great need of elucidation. G. W. Lamplugh.

Bridlington Quay.
November 4th, 1902.

'CALCRETE.'

Sir,—"Murder will out," whether of person or language, and the appearance in the October number of the *Irish Naturalist* of a new word for which I am responsible makes requisite an open confession. The word is 'calcrete,' applied in this instance by a friend who has become accustomed to the term through our conversation, and has trustfully used it as a 'good' word in describing the shelly drift-gravels near Dublin. The indiscretion will be repeated, by my colleagues as well as myself, in the forthcoming new edition of the Geological Survey Memoir on the neighbourhood of Dublin, and preliminary explanation and definition seems therefore desirable. In the drifts around Dublin, as in most places where in like manner limestone-débris enters largely into the composition of the superficial deposits, the sand-and-gravel beds are often cemented sporadically into hard masses by solution and redeposition of lime through the agency of infiltrating waters. In order to indicate this condition on the field-maps a terse expression was sought to replace such long and awkward circumlocutions as 'conglomerated gravel,' 'calcareous concreted gravel,' etc., and for this purpose the abbreviation 'calcrete' was invented and found adequate. Other workers under similar conditions may find the word equally serviceable, and to them I therefore recommend it.

Moreover, I have the hardihood to suggest that the term might be complemented by equivalents,—'silcrete,' for sporadic masses in loose material of the 'greywether' type, indurated by a siliceous cement; and 'ferricrete' when the binding substance is an iron-oxide. I will grant that these terms are etymologically somewhat imperfect, but the inconvenience of an additional syllable would be a more weighty objection where expressive brevity is of prime consequence. G. W. Lamplugh.

Bridlington Quay.
November 4th, 1902.

RADIOLARIAN CHERTS IN THE CULM.

SIR, — I wish to call attention to a Review of the Geological Survey Memoir on "The Geology of the Country around Exeter" which appeared in your November number, pp. 524–525.

Probably through a printer's error the title (Explanation of Sheet 325) has been rendered "(Explanation of Sheet 25)."

Lower Culm-measures are said to "embrace a large extent of the Exeter area" dealt with in this Memoir. As a matter of fact the Lower Culm rocks occupy a very small area on the south-western margin of the map; and, as far as I know, they have not been searched for Radiolaria by my friend Mr. Fox, although he records their discovery in many places in the map to the south (Sheet 339).

As regards being up-to-date, the literature of the Culm-measures would have shown the writer the groundlessness of the charge that I have not acknowledged my friend Mr. Fox's discoveries.[1]

METHLEIGH, ST. AUSTELL, CORNWALL. W. A. E. USSHER.
November 23rd, 1902.

OBITUARY.

WILLIAM GUNN, F.G.S.

BORN SEPTEMBER 27, 1837. DIED OCTOBER 24, 1902.

MR. WILLIAM GUNN joined the staff of the Geological Survey in 1867 under Murchison, and was occupied for many years chiefly in the survey of the Carboniferous rocks in West Yorkshire, Durham, and Northumberland. In 1884 he was promoted to the rank of Geologist, and was transferred to Scotland, taking up work in Bute, and proceeding subsequently to the North-West Highlands. In later years he was engaged in the Survey of the Isle of Arran, and among other interesting discoveries he found evidence of a volcanic vent of Tertiary age which enclosed fragments of Rhætic and other Secondary strata, not previously recognized in the island. Mr. Gunn was author of memoirs published by the Geological Survey on Belford, Holy Island, and the Farne Islands, on the coast south of Berwick-on-Tweed, on Norham and Tweedmouth, and he was joint author of memoirs on Wooler and Coldstream, on Ingleborough, and on Corval in Argyllshire.

His other contributions to geology related for the most part to the rocks which he had studied in the course of his official work. He thus communicated occasional papers to the Transactions of the Edinburgh Geological Society, the Berwickshire Naturalists' Club, the Glasgow Geological Society, the Geological Society of London, and the GEOLOGICAL MAGAZINE.

All his work was of a thorough and most painstaking character. He enjoyed the active outdoor life of a geologist, and continued to carry on field-work until near the close of his life, when, having attained his 65th year, the age-limit obliged him to retire from the service. Only last year he was promoted to the rank of District Geologist.

[1] [The Reviewer doubtless referred only to Memoir on Sheet No. 325, in which the name does not seem to occur.—EDIT. GEOL. MAG.]

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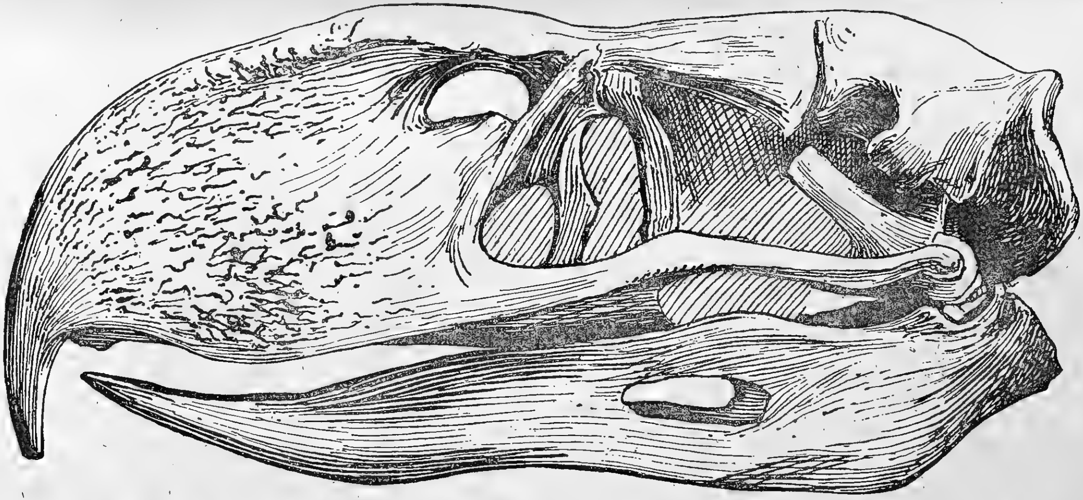

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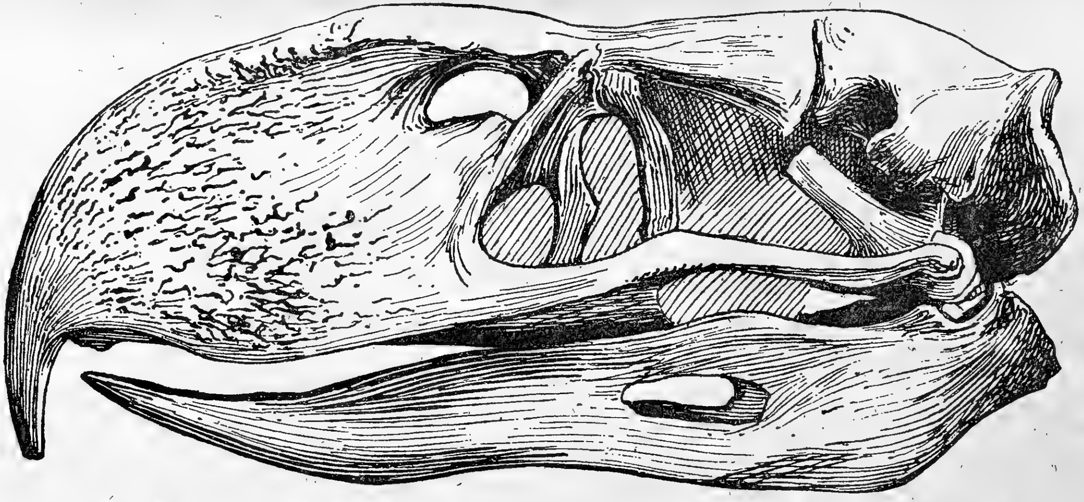

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