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DECADE V. VOL. VIII.

JANUARY—DECEMBER, 1911.

THE

GEOLOGICAL MAGAZINE

OR

Monthly Journal of Geology:

WITH WHICH IS INCORPORATED

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EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., F.R.M.S.

LATE OF THE BRITISH MUSEUM OF NATURAL HISTORY; PRESIDENT OF THE PALÆONTOGRAPHICAL SOCIETY; ETC., ETC.

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No. I.—JANUARY, 1911.

ORIGINAL ARTICLES.

I.—The Gulf of Suez.[1]

By John Ball, Ph.D., D.Sc., F.G.S. of the Geological Survey of Egypt.

IN a previous paper published in this Magazine,[2] I gave reasons for the belief that neither the Gulf of Suez nor the valley of the Nile owes its origin to trough-faulting, as was at that time generally supposed. The skeleton of the argument was as follows:—

1. Extensive faulting at the faces of the scarps of the Nile Valley and Gulf of Suez cannot be held to be evidence of trough-faulting, since the same can be observed along the scarps of the Wadi Araba, the structure of whose floor shows it to be an eroded anticline, and the faults along its scarp-faces to be merely huge landslips.

2. The faulting observable immediately along the coast of the Gulf of Suez is of an exactly similar nature to that above mentioned, and along part at least of the gulf the strata dip away from the sea on the opposite coasts, leading to the inference that the Gulf of Suez is, like the Wadi Araba, an eroded anticline.

3. If it be granted that the Gulf of Suez is not a trough-fault, the argument against the Nile Valley being a trough-fault is strengthened, the support of parallelism being removed.

A discussion of the paper with various fellow-workers has indicated entire agreement as to the Nile Valley having been cut out by erosion, but at the same time has shown a tendency to suspension of judgment regarding the origin of the Gulf of Suez. I have therefore searched diligently for further facts which might throw light on the origin of the gulf. Since writing my last paper I have spent a season surveying in the neighbourhood of Gebel Zeit. Though the work was confined, by other considerations than geology, to a small part of the Egyptian side of the gulf, and has in consequence not furnished much additional evidence, I may say that such observations as I was able to make were all to my mind corroborative of the conclusion to which I had already been driven, viz. that the Gulf of Suez owed its origin to erosion and not to trough-faulting; for example, I remarked that the Nubian Sandstones on the north-east flank of Gebel Zeit dip strongly away from the gulf, which one would not expect them to do if the gulf had been faulted down. Since more extended field

[1] Communicated by permission of the Director-General, Survey Department, Egypt.
[2] Geol. Mag., Dec. V, Vol. VII, pp. 71–6, 1910.

observations were not possible at present, it occurred to me that something in the way of evidence might be gathered from a careful study of soundings in the gulf. As one of the world's great highways of commerce, the Gulf of Suez has been thoroughly sounded by the British Admiralty, and the Gulf of Akaba and the Red Sea have likewise been subjected to sounding observations, though of a less degree of closeness. I therefore took the large-scale Admiralty chart of the Gulf of Suez,[1] and, using the soundings as a guide, drew in the contours of the sea-bottom at 10 fathom intervals. I also examined the smaller-scale chart[2] on which the Gulf of Akaba and the north part of the Red Sea are shown, and compared the soundings in these parts with those of the Gulf of Suez. The results furnish, I think, a strong argument for the erosive origin of the Gulf of Suez.[3]

The first striking conclusion from an examination of the charts is the extreme shallowness of the Gulf of Suez as compared with the Gulf of Akaba and the Red Sea. The deepest sounding in the Gulf of Suez is a solitary one of 63 fathoms south-east of the Island of Jubal, and even this is a very local deepening,[4] for there is no sounding indicating a depth of over 50 fathoms at any other point in the gulf; while the Gulf of Akaba is a deep trough with a maximum depth of over 700 fathoms, and the Red Sea, even close south of the Gulf of Suez, goes down to over 600 fathoms. The remarkable contrast between the Gulfs of Suez and Akaba in regard to depth is shown in the transverse section across the two gulfs, drawn to a natural scale in Fig. 1. A subsidence of only 100 metres, which is nothing more than can be accounted for by secular oscillation of the earth's crust, such as is known to be going on in many parts of the world, would leave the Gulf of Suez high and dry, while the Gulf of Akaba and the Red Sea would be but little altered in outline, and would remain very deep seas. Further, it will be seen from the longitudinal sections, shown in Fig. 2, that while in the case of the Gulf of Suez there is a gradual fall to the greatest depth at the mouth, and a final huge drop to the Red Sea, in the case of the Gulf of Akaba we have a trough with its greatest depth near the centre, and a transverse 'horst' separating that trough from the Red Sea. Can anyone conclude that the two gulfs have a like origin? To explain so deep a trough as the Gulf of Akaba, devoid of outlet for over a kilometre of its depth, a local subsidence may well be invoked, more especially as it forms the geographical continuation of the Jordan Valley, as to whose origin in a trough subsidence there can, I suppose, be no doubt. But the Gulf of Suez is an entirely different matter. When we realize that the Gulf of Suez is neither parallel to, nor a prolongation

[1] Admiralty Chart No. 757, revised to 1908.

[2] Red Sea Sheet No. 1, Admiralty Chart No. 8*a*, revised to 1897.

[3] It is remarkable that these same charts appeared to Mr. Barron and Dr. Hume to support the idea of a trough-fault origin for the gulf, which is just what I consider the charts disprove. See *Topography and Geology of the Eastern Desert of Egypt, Central Portion*, Cairo, 1902, p. 213. My colleagues would, I think, have been driven to an opposite conclusion had they drawn in the contours of the entire gulf, or constructed a section across it to a natural scale.

[4] Such local deepenings occur in many river valleys, usually in consequence of a waterfall; an example occurs in the Nile Valley below the First Cataract.

Fig. 1. Transverse section from the watershed range of the Eastern Desert of Egypt, across the Gulf of Suez, Sinai, and the Gulf of Akaba to the Arabian coast. Plotted to a natural scale. The horizontal line forming the base of the diagram is 2 miles below sea-level.

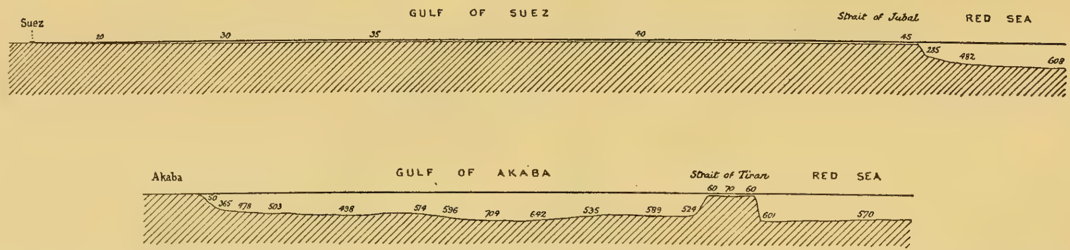


Fig. 2. Longitudinal sections of the Gulfs of Suez and Akaba, drawn to the same scale for comparison. The vertical scale is ten times the horizontal one. The figures give the depth in fathoms from the Admiralty soundings.

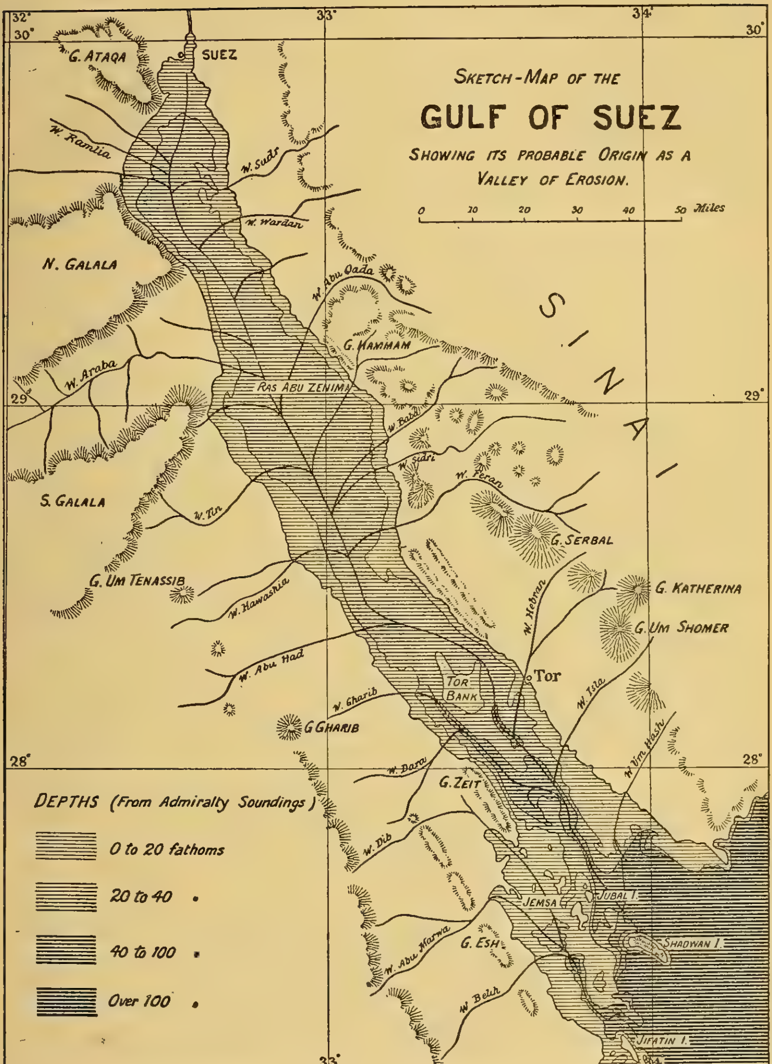
of, any known area of trough-subsidence other than the Red Sea, from which sea the contrast in width and depth is so remarkable as to suggest genetic independence rather than community of origin; when we contrast the shallowness of the Gulf of Suez with the more than tenfold greater depth of the Gulf of Akaba; above all, when we remember that secular movements are known to have gone on comparatively recently in the district,[1] and that such a movement downwards of less than 100 metres is all that is necessary to account for the submergence of dry land to form the existing gulf; we must feel hesitation at pronouncing the Gulf of Suez to be a trough-subsidence.

But that is not all. Let us consider the contours of the floor of the Gulf of Suez, shown in the sketch-map on p. 5. This map is reduced from a much larger one which I made, and the smallness of the scale has rendered it impossible to show the contours at 10 fathom intervals; I have therefore shown only the 20, 40, and 100 fathom lines, which indicate the shape of the bottom of the gulf sufficiently well for the purpose of discussion. The shape of the floor of the gulf is exactly that of a great flat-bottomed valley such as the Wadi Araba or the Wadi Qena. Even where the slope downwards from the shore towards the centre of the gulf is steepest, as for instance near Gebel Zeit, the 20 fathom contour is seldom within half a mile of the coast, which only corresponds to a slope of about 1 in 40; and as the slope of the adjacent land is greater than this, there is no sudden deepening, such as might indicate a trough-fault, but rather a general continuity of slope from hill-top to sea-bottom.[2] Moreover, the fall of the sea-bottom lengthwise is practically continuous from Suez to the Red Sea.[3] Another suggestive feature is that there are indentations of the contours of the floor of the gulf opposite the mouths of many of the wadies draining into it; these indentations are not very evident on the small-scale map, owing to the fewness of the contours which can be shown; but they are more marked on the larger scale, where the 10 and 30 fathom lines are drawn in. It is extremely unlikely that the bottom of the gulf has been eroded in this curious manner by deep currents; the tendency of the sea will rather have been in the direction of the silting-up of any pre-existing deep hollows. What is the only other deduction? Must we not conclude that the Gulf of Suez is a submerged valley of erosion, by which the wadies now draining from Egypt and Sinai to the gulf formerly emptied their contents by trunk-channels into the Red Sea near what is now the Island of Shadwan? I have drawn the main lines of this suggested former drainage system in the sketch-map, from which I think the connexion between the existing wadies and the shape of the floor of the gulf will be evident.

[1] Evidence of raised beaches. See Barron & Hume's *Eastern Desert*, p. 139.

[2] Recent coral reefs have in parts given rise to small steps in the slope near the present water-line, but it will be perceived that these have nothing to do with the argument.

[3] The only break in the continuous slope down the gulf as shown by 10 fathom contours is a slight rise of a few fathoms a little north of latitude 28. It is probable that the soundings may have missed the very deepest parts here, or that silting or coral-growth has filled up the hollows to the thickness of a few fathoms.


SKETCH-MAP OF THE
GULF OF SUEZ
SHOWING ITS PROBABLE ORIGIN AS A VALLEY OF EROSION.
0 10 20 30 40 50 Miles
32°
33°
34°
30°
29°
28°
SUEZ
G. ATAQA
W. Ramlia
W. Sudr
W. Wardan
N. GALALA
W. Abu Qada
G. HAMMAM
SINAI
W. Araba
RAS ABU ZENIMA
W. Baba
W. Sidri
W. Feran
S. GALALA
W. Tih
G. SERBAL
G. UM TENASSIB
W. Hawashia
W. Hebran
G. KATHERINA
G. UM SHOMER
W. Abu Had
Tor
TOR BANK
W. Gharib
W. Isla
G GHARIB
W. Um Hash
W. Dara
G. ZEIT
DEPTHS (From Admiralty Soundings)
0 to 20 fathoms
20 to 40
40 to 100
Over 100
W. Dib
JEMSA
JUBAL I.
SHADWAN I.
W. Abu Marwa
G. ESH
W. Belih
JIFATIN I.

In his recent paper dealing with the Nile Valley[1] my friend and colleague Dr. Hume, while agreeing entirely with me in the erosive origin of that valley, has mentioned two considerations which cause him to hesitate about accepting a similar origin for the Gulf of Suez. These are, firstly, the distribution of the Miocene beds, especially their absence from the Wadi Araba, and secondly, a difficulty in conceiving of erosion cutting through the dome or anticline which existed across the gulf, unless aided by fracture. These difficulties are easily explained.[2] As regards the distribution of the Miocene, much has yet to be done before a true picture of it is obtained. Where, as usually happens, the Miocene beds overlie older limestones, the limits are very difficult to trace in the field, the fossils, which are often extremely scarce, being the only guide. But from Mr. Barron's maps of Western Sinai it is apparent that the Miocene beds which cap the hill-ranges of the Sinai coast of the gulf dip inland, and thus we must infer that the deposition of the Miocene limestones antedated the folding which gave rise to the dome or anticline. Now since there is every reason to believe that the erosion of the Wadi Araba, like that of the gulf, occurred after the folding, the absence of Miocene beds from it is exactly what the erosion hypothesis requires for its support. Turning next to the conception of erosion cutting through the dome without fracture, I would remark that fracture at the top of the dome or anticline is quite possible; in fact, the weakening of the beds at the top of the arch under tension is probably the key to why the drainage-line assumed its actual position. I am not, however, now concerned with the causes which determined the position of the drainage-lines along which erosion went on, my point being only to show that erosion, and not trough-faulting, has removed the beds which formerly stretched across the gulf. And fracture is not trough-faulting. The fracture at the top of an anticline is brought about in an entirely different manner from a trough-fault, the one being due to tension by bending of the beds under tangential pressure, the other to shearing by radial subsidence. Moreover, we cannot get away from the fact that the Wadi Araba has actually cut through the same dome or anticline, its drainage-line, in fact, going inwards from the edge to near the centre of the dome; and what has actually happened in the case of the Wadi Araba is surely not inconceivable, but rather likely, in the case of the valley which gave rise to the Gulf of Suez.

I would remark that in arguing that the Gulf of Suez is not due to trough-faulting, and that the faults which bound it along the edge of the North Galala plateau are merely huge landslips and not true faults, I am very far from stating that no true faults are to be found in the lands bordering the gulf. True faults do occur on both sides, especially in Sinai, and possibly they may exist even in the gulf itself;

[1] Geol. Mag., Dec. V, Vol. VII, p. 388, 1910.

[2] I regret that owing to our separation for a long period I did not have the opportunity of explaining these difficulties to Dr. Hume before he published his paper. To English readers it will appear strange, but when one of two workers is in Cairo and the other is in the desert, they are frequently much further apart as regards time of communication than if one were in England and the other in Khartoum.

but my point is that they have no direct genetic connexion with the Gulf of Suez as we now know it, having taken place at a prior epoch to that of the erosion and submergence of the gulf. The rift-valleys of Eastern Sinai, observed by Dr. Hume,[1] are all parallel to the Gulf of Akaba, which is admittedly a trough-subsidence, and therefore show a true relationship with that gulf. But no undoubted trough-fault has ever been observed parallel to the Gulf of Suez, and there is no evidence for the existence of a second system of rifts inclined at a considerable angle to those of the great Dead Sea system, except the Red Sea itself. In his exploration of Western Sinai Mr. Barron[2] regarded only one line of valleys as safely attributable to 'rift', and the chief factor on which he based his judgment was parallelism with the Gulf of Suez. But to use this as any support in regarding the Gulf of Suez itself as a trough would be to argue in a circle.

The view of an erosive origin for the Gulf of Suez is, I think, now supported by strong evidence. As to its being an anticline, the evidence is but little less conclusive. The strata of the Galala mountains on the one side and those of Gebel Hammam on the other dip away from the gulf, so that in the north at least the gulf possesses an anticlinal structure. In the south part we have at present less complete data, and it is quite likely that the anticlinal structure there may be less simple and less pronounced than it appears to be in the north. But such observations as have been made are all in the direction of a general similarity of structure right down the gulf. Thus the beds forming the long coast-ranges north of Tor all dip away from the gulf, exactly as do those of Gebel Hammam, and the Nubian sandstones at the north end of Gebel Zeit likewise dip inland; while such scanty information as we possess from the islands near the Strait of Jubal all tend to indicate that an anticlinal structure is present there. The numerous borings now being made by prospecting companies on the islands will, we may hope, soon lead to more complete knowledge of the structure and nature of the rocks composing them.

It is interesting to see how easily we may trace the later geological history of North-Eastern Egypt on the view of the erosive origin of the Nile Valley and Gulf of Suez, together with those secular oscillations of the earth's crust in the district of which we have equally strong evidence in the numerous observations of Beyrich, T. Fuchs, Schweinfurth, Hull, and others. Any attempt at the reconstruction of the geological history of this part of Egypt must take account of the following facts,[3] in addition to those which I have brought forward to prove the erosive origin of the Nile Valley and the Gulf of Suez :—

1. The great depth of the bed-rock channel of the Nile in Lower Egypt, as proved by numerous trial borings; these borings all show a great thickness of sands and gravels to intervene between the present bed of the Nile and the bed-rock of its channel.

[1] "The Rift Valleys of Eastern Sinai": International Geological Congress, Paris, 1900.

[2] *Western Sinai*, p. 180.

[3] Most of these observed facts will be found summarized in Suess' *Face of the Earth*, English translation, vol. i, p. 380, 1904.

2. The occurrence of Pholas borings, discovered by Professor Schweinfurth, in the slopes of the Mokattam Hills, near Cairo, at an altitude of about 60 metres above the present sea-level.

3. The occurrence of sands with an Erythræan fauna of Pliocene age, near the pyramids of Giza, 64 metres above the present sea-level, as shown by Beyrich and T. Fuchs.

4. The mingling of Mediterranean and Erythræan faunas in the shell-beds near Suez, as proved by the researches of Issel.

5. The occurrence of alluvial deposits with Nile shells on the Isthmus of Suez.

6. The traces of an ancient sea-level, 60 metres above the present one, near Suez, observed by Professor Hull.

7. The raised beaches of Pleistocene age on the shores of the Gulf of Suez, some of which are 158 metres above the present sea-level, according to Barron and Hume's measurements.

I shall show that all these various facts can be explained easily and naturally as consequences of erosion and secular oscillation of the earth's crust, without invoking the aid of any such catastrophic changes as the letting-down of large tracts by trough-faults.

Accepting the erosive origin of the Gulf of Suez as sufficiently indicated by the considerations I have already given, we may first inquire into the probable antiquity of the valley whose submergence gave rise to the gulf. It cannot be older than the Miocene, for Miocene beds cap hills on both coasts, and appear to have undergone the folding which I have mentioned as evidence of the anticlinal structure of the gulf. The earliest date possible for the commencement of the erosion must be the latter part of the Miocene period, when a great rise of the crust took place in North-East Africa, with folding and faulting. This folding and faulting, far from producing the Gulf of Suez by subsidence, raised the land-surface over its present site. The folding probably had some part in determining the course of the drainage-lines, by weakening of the folded strata; but the actual valley, whose submergence at a later date was to give rise to the gulf, was yet to be excavated by river-action. The erosion of the valley may well have gone on during the latter part of the period of elevation, as well as after it. The drainage down what is now the gulf would continually cut backwards (i.e. northwards, towards what is now the isthmus), gradually lowering the land-surface; but it is clear that so long as the gulf was a river-valley, the Isthmus of Suez must have been relatively high land. The length of the gulf from north to south is roughly 300 kilometres. Assuming that when the valley had cut itself back as far as Suez, it had an average slope of 1 in 5,000 (which is about twice as steep as the slope of the Nile between Cairo and Aswan), the land at Suez must have been at least 60 metres above sea so long as the gulf remained unsubmerged.

Now while the Gulf of Suez was thus being eroded as a river-valley, the Nile would be cutting its channel. The amounts of erosion evidenced in the Nile Valley and in the gulf are of the same order of magnitude, and the two valleys were most likely approximately contemporaneous in origin. And if the rise of land to 60 metres or more above its present level was general over the northern part of Egypt, as is most likely, the Nile must have eroded its channel 60 metres or more below its present level in order to reach the sea; we have thus a simple explanation why the bed-rock channel of the Nile in Lower Egypt is so deep.

A great part of the erosion of the Nile Valley, and a still greater part of that of the Gulf of Suez, must have been accomplished between the Miocene and Pliocene epochs, when the land was at its maximum elevation. It is, indeed, likely that there has been practically no erosion of the bed-rock main channel of the Nile in the neighbourhood of Cairo, nor of the central line of the Gulf of Suez, since Pliocene times; and this not because of any cessation of the action of erosive forces in the district generally, but merely because these forces have been unable to exert themselves in these particular places; for the bed-rock channel of the Nile near Cairo has never since that time been above sea-level, and the Gulf of Suez has been continually an arm of the sea. Erosion was, however, going on with great vigour throughout the Pliocene and Pleistocene ages in all the tracts which remained unsubmerged. In the case of the Nile Valley the river continually cut backwards higher up its course, and the lateral drainages to it were actively eroding their channels, while there were doubtless migrations of the stream from side to side, tending to the continual broadening of its valley, in which river erosion was aided by weathering and landslips at the faces of the confining scarps. In the case of the Gulf of Suez the lateral drainages only have been active in erosion since the submergence of the trunk channel, but the vast extent to which this action has gone on is attested by the size of the Wadi Araba and the breadth of the sloping plains, covered with sand and gravel, which stretch in most places between the hills and the shores of the gulf.

In Pliocene and early Pleistocene times a subsidence of the land took place, submerging the lower part of the Nile Valley and the whole Isthmus and Gulf of Suez. The Pliocene sea entered the Nile Valley, deposited the Clypeaster sands near the pyramids, and gave rise to the Pholas borings in the face of the Mokattam Hills. The northern parts of the Nile Valley being submerged, the river would have its velocity checked by entering the sea at an earlier point of its course than formerly, and would thus be forced to deposit the sands and gravels which now overlie the bed-rock in the lower reaches of its channel. The sinking of the land to a depth of over 60 metres, which is necessary to account for the Clypeaster sands, the Pholas borings, and the old shore-line near Suez, must have submerged the Isthmus of Suez, and brought about that connexion between the Mediterranean and Red Seas which is evidenced by the mingling of the two faunas. The same sinking accounts for the raised beaches found along the shores of the gulf; to explain the higher beach, 158 metres above present sea-level, we have only to assume, what is indeed most likely, that the downward movement varied in amplitude in different parts, and reached its maximum amount in the district where this higher beach is found.

In the later Pleistocene period subsidence ceased, and elevation of the land set in. The Isthmus of Suez again became dry, and the two seas were again separated as we find them to-day. The Nile mouth gradually progressed northwards as the land rose, the river cutting its present channel in the sands which it had itself previously deposited; and when the Isthmus of Suez was just about to emerge from the sea, a part of the river may well have discharged itself eastwards towards what was then the junction of the two seas, thus accounting for the alluvial deposits and Nile shells which occur on the isthmus.

There is some evidence that the upward movement of land in North-Eastern Egypt which went on in later Pleistocene times has now ceased, and given place to a slow sinking. Lyell[1] mentions the positions of tombs near Alexandria and the ruins of towns half submerged in Lake Menzala as evidence of this, and lately Mr. Villiers Stuart[2] has observed that certain areas of the northern delta, which carried a dense population in Roman times, are now uninhabited and only a few centimetres above sea-level.

I venture to think that the outline which I have given above of the later geological history of the Gulf of Suez explains, in a perfectly natural manner, all the facts of observation which it has hitherto been sought to explain on the trough-fault theory, and with less straining of probabilities. Our knowledge of the detailed structure of the gulf is far from being of that completeness which is desirable in a district which may possibly become one of the great oilfields of the world; but a working hypothesis of some sort as to the origin of the gulf is desirable, and I urge that erosion and secular oscillation is a far better working hypothesis, in the light of presently known facts, than local subsidence by trough-faulting.

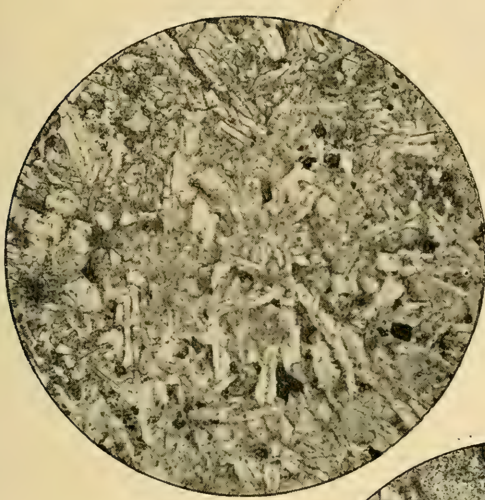
II.—Observations on some Basic Dykes and their Bearing on certain Problems of Rock Genesis.

By F. P. Mennell, F.G.S.

(PLATES I AND II.)

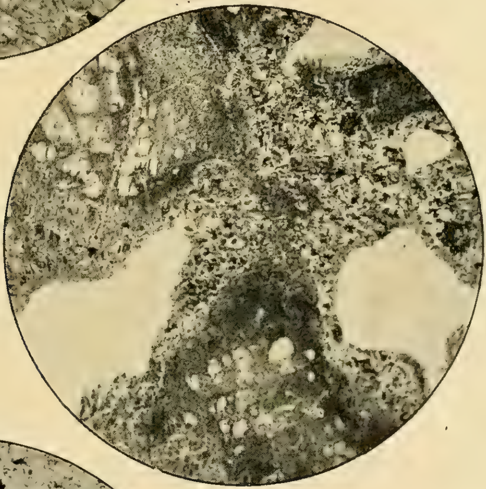
It is a common feature of the dolerite dykes in Rhodesia, especially where they penetrate the great granite masses of the country, that they show, even in hand-specimens, the presence of quartz. Usually this quartz occurs in good-sized corroded fragments which are quite obviously xenoliths derived from the surrounding rocks. Of this a fine example is to be seen close to Bulawayo Railway Station, where a small dyke is at one point so full of quartz fragments, up to several inches across, as to resemble a conglomerate more than an igneous rock. Other parts of this same dyke and many other basic dykes throughout the country contain quartz, either in separate granules or in the form of micropegmatite, whose origin is not so clear. It is with a view to elucidating this point that the present notes have been put together. They deal entirely with two intrusions cutting the great Matopo granite mass. The relative ages of the dykes and the granite cannot be given in precise terms, as the data

[1] *Principles of Geology*, 10th ed., vol. i, p. 438, 1867.
[2] *Cairo Scientific Journal*, 1909, p. 230.



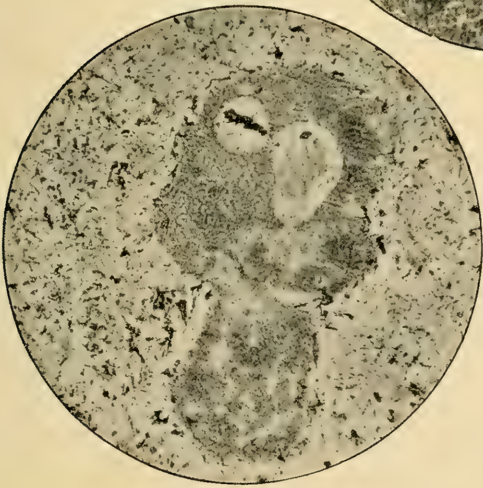
1

[1737.] Fine-grained Dolerite, Antelope Road. × 20 diam.



2

[1738.] Granite xenolith, Antelope Road. ×20 diam.



3

[1701.] Modified Dolerite, with xenocrysts. Kahlele's, Matopos. × 20 diam.

Basic Dykes, Rhodesia.

are much too imperfect. The granite is presumably of Archæan age, and the dykes may be as late as Jurassic, though they may be older. That there was, however, a very great interval of time between the consolidation of the granite and the intrusion of the dykes is beyond dispute. We are certainly not dealing with products of related magmas or of the same general period.

Antelope Road Intrusion. This small intrusion of dolerite is situated about 100 yards east of the road, some 3 miles from the Matopo Hotel. It is a rather lenticular mass with straggly offshoots, and is fine-grained throughout, being markedly chilled at its junction with the granite, which is well exposed in a stream bed and on its banks. At the contact the granite has its felspars reddened and its quartz assumes a particularly glassy aspect, while the dolerite encloses numerous xenoliths of the granite a foot or so in diameter. In spite of chilling it has succeeded in insinuating itself among the constituents of the xenoliths to a most remarkable extent, so much so that in extreme cases almost every individual quartz and felspar grain is isolated from its neighbours by dark strings of basic material.

Microscopic Features. The dolerite is a granular medium- to fine-grained type without any features calling for special remark. One slide shows its junction with a granite xenolith [1737]. Pl. I, Fig. 1 gives a good idea of its appearance, and it need only be noted that much of the augite is uralitized. The edge of the granite xenolith is illustrated in Fig. 2. As will be seen, the fine-grained dolerite forms a kind of ground-mass in which the quartz and felspar of the granite are embedded like phenocrysts: the corrosion of the quartz and the incipient disintegration of the felspar are well shown. [1738] is cut from the central part of the same xenolith, several inches from the edge. Its interpenetration by the basic material is as conspicuous as near the margin. The matrix is of very fine-grained dolerite, with its ferro-magnesian constituent represented by pale-greenish hornblende and the iron-ore converted into leucoxene. Through this are distributed numerous xenocrysts of much corroded quartz, usually surrounded by a rim of fine-grained material, and others of felspar. The last are very cloudy in appearance, so much so as to be almost opaque, but the twin striations are not entirely obscured.

[1735.] This represents the main mass of granite within a few inches of the contact. It shows reddish altered-looking felspars, very glassy quartz, and strings of dark greyish-green material, which at once suggests the neighbouring fine-grained dolerite, intercalated among the quartz and felspar grains. Under the microscope the whole presents the appearance of incipient melting. The felspars are cloudy and altered-looking, but the twin striations are often tolerably well preserved, and the grains which show them can frequently be identified as the usual oligoclase of the Matopo granite, with straight, or nearly straight, extinction for both sets of twin lamellæ. Others, again, can be identified with considerable confidence as microcline, though the cross-hatching is only occasionally recognizable. The quartz is remarkably free from inclusions. Where, however, doleritic material is present, it is frequently much corroded and has minute needles of a mineral which is probably hornblende penetrating its edges. The doleritic material is composed of the usual lath-shaped felspars, but, as in the previous case, the ferromagnesian mineral is now represented by hornblende. Between the quartz and felspar grains there is always a reaction rim, usually about $\frac{1}{10}$ mm. broad. In some instances this has consolidated as a fine micropegmatite, a most important observation in view of the phenomena to be described below.

The Dyke near Kahlele's. We may now pass on to the consideration of another intrusion near the central part of the Matopo granite mass. It is a much larger one than that furnishing the specimens previously referred to, running for several miles in a north and south direction through Kahlele's Old Kraal. The granite is here remarkably uniform and of the normal type prevalent throughout the Matopos, consisting of quartz, microcline, oligoclase, and biotite, with sphene, apatite, and orthite as accessories. The width of the dolerite dyke usually exceeds 100 feet, and it forms the bottom of a big depression with steep granite kopjes rising on each side to heights of several hundred feet. The tract from Fort Usher to the Blanket Mine follows this depression along the whole length of the dyke.

Microscopic Features. The normal coarser central portions of the intrusions [1352 and 1700], as seen along the road north of Kahlele's, afford examples of rather an unusual type of dolerite. Under the microscope the rock is seen to consist of olivine, enstatite, augite, and felspar in roughly equal proportions. The olivine occurs partly in good-sized grains showing a tendency to crystal outline, and partly as inclusions in the pyroxenes. It is very fresh; some lines of separated magnetite can be observed, but there is little serpentinization. The enstatite and augite occur in rather large plates. Both are quite colourless, and are apt to be penetrated to some extent by the felspars. These generally show pericline as well as albite lamellation, but are not very abundant, and the rock approaches the picrites in this respect. Small flakes of a colourless to deep-brown mica may be observed among the felspars. It may be noted here that further to the south slices show that the dyke has undergone considerable alteration. The ferromagnesian minerals are uralitized, and the production of much epidote may be observed in many places. The alteration was therefore due to deep-seated hydrothermal agencies, and not to weathering.[1] At the point we are immediately concerned with the rock is remarkably fresh, as in the specimens described above, having a black sparkling appearance in hand-specimens. As one approaches the granite margin, its texture becomes much finer, and especially towards the west side xenoliths become of frequent occurrence. They first of all appear as more or less rounded or corroded patches of quartz or felspar, or both, in the black fine-grained dolerite, but the rock passes into a type with a much lighter ground-mass, as if a considerable amount of the granitic material had been assimilated, as there can be no doubt was the case. Eventually we encounter a rock which may be regarded as contact-altered granite, and which does not look in the field as if it had been much modified.

[1] Compare *Introduction to Petrology*, p. 177.

Under the microscope this is, however, seen to be far from the truth. To the microscopic details of the specimens we may now turn.

The Mixture Rocks. [1346.] This slice is taken from a rather fine-grained rock nearer to Kahlele's Kraal than most of the others. In the hand-specimen it appears a perfectly normal dolerite, consisting of felspar and augite, and in some parts of the slice there is little to disturb such a conclusion. However, there are several large xenocrysts of felspar, one so nearly dissolved that without the evidence of the others its true nature might not be suspected. These felspars have an altered appearance, and a very peculiar mottling, evidently due to the heating they have undergone, but the cross-hatching of microcline is nevertheless recognizable. Two quartz xenocrysts about 3 mm. long also occur. The most interesting feature of the felspar xenocrysts is their recrystallization along their edges into clear felspar, contrasting sharply with the cloudy interior. This sometimes shows distinct crystal faces, and is idiomorphic towards quartz and micropegmatite. The last is somewhat abundant, and in view of the presence of xenoliths in all stages of solution, obviously derived from the surrounding granite, there can be little doubt that it results from the complete absorption of others, especially bearing in mind the relation already noted to the latter growths of felspar. The patches where micropegmatite is most abundant generally show some larger grains of quartz, and are, moreover, characterized by the presence of small biotite flakes instead of the augite of the normal doleritic patches.

Pl. I, Fig. 3 [1701]. This represents a further stage of admixture. In hand-specimens it is a black fine-grained rock enclosing many conspicuous xenoliths of granitic material. The ground-mass has under the microscope a rather granular appearance (see Fig. 3), but is permeated everywhere by fine micropegmatite. Some basic felspar remains, but biotite is the ferromagnesian mineral. Most of the quartz xenocrysts and some of those of felspar are composite. Beautiful examples are to be seen of corrosion cavities in the felspars, filled with micropegmatite, the clear felspar of the latter being in optical continuity with the remainder of the xenocryst. This is illustrated in Fig. 3, where two such cavities are shown in a crystal of oligoclase, which has the characteristic cloudy mottled appearance of all the felspar xenocrysts of this intrusion.

Slice [1703] is similar to the above. It has a very interesting feature in the presence of an orthite (allanite) crystal, which shows as an oval dark patch at the edge of Fig. 4. Orthite is an almost constant accessory in the Matopo granite,[1] and is well developed in the rock round this particular intrusion.[2] Slice [1351] is also similar. It has numerous examples of cloudy felspar xenocrysts extinguishing simultaneously with the fresh felspar of the surrounding micropegmatite, which last forms the bulk of the rock. One corrosion cavity has an edging of fresh felspar with well-developed crystal faces idiomorphic towards the enclosed micropegmatite.

[1] See *Geology of Southern Rhodesia*, 1904, p. 29.

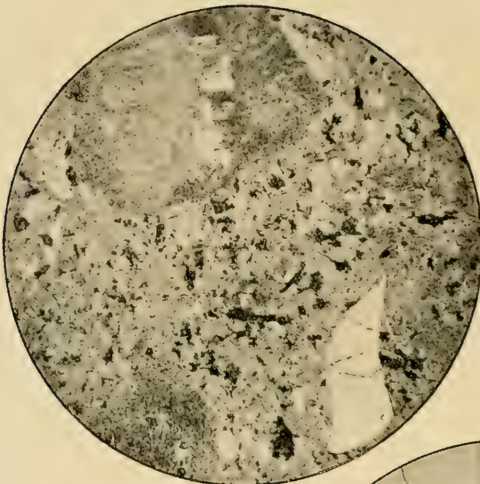
[2] Geol. Mag., January, 1910, p. 18, and Pl. V, Fig. 10.

[1702.] This specimen has a dark-grey crystalline ground-mass, with enclosed patches of quartz and felspar, and although the rock it represents forms large masses near the edge of the dyke, it is evident they are to all intents and purposes partly absorbed granite xenoliths. It is remarkable how little basic material can be definitely identified under the microscope, though the dark colour of the rock is strong evidence of its presence. The ground-mass is made up of fine- to medium-grained micropegmatite with minute scattered biotite flakes. The cloudy felspars derived from the granite are frequently in crystallographic continuity with those of the surrounding intergrowths, and these at times show the microcline cross-hatching. Zoning can sometimes be observed, a wave of extinction starting at the outer edge of the cloudy felspar, and passing gradually across the micropegmatite fringe. The nucleus itself is free from the zoning, as are the felspars of the surrounding granite mass. A well-developed crystal of orthite, about $\frac{3}{10}$ mm. in length, is present in this slice, and shows very little alteration. Slice [1704] shows altered crystals of sphene, which, like the orthite, is a constant accessory in the granite. It may be remarked that slices 1702 and 1704 would both be taken to represent fairly typical granophyres, in Rosenbusch's sense of the term, without a knowledge of their field relations. (See Fig. 5.)

[1705.] This is made up almost entirely of granitic materials. Indeed, the ground-mass really shows no traceable doleritic materials. It is quite subordinate in amount to the xenocrysts, or phenocrysts, or whatever they are most correctly to be termed, and chiefly consists of reaction zones between the quartz and corroded felspars, which afford beautiful examples of micropegmatite (see Fig. 6). Apatite, sphene, and orthite are among the constituents of the rock as in the surrounding granite mass. Biotite is freely distributed in aggregates of small flakes, but neither in this case nor in any of the other specimens does it occur as actual xenocrysts. The original crystals have evidently always been melted down, or otherwise destroyed, and it has then crystallized out afresh amongst the ground-mass. Before closing, it may be well to remark that in no case has micropegmatite been found in any but marginal modifications of the Matopo granite, and in these latter it is always of the vermicular type which seems characteristic of rather rapid cooling under very deep-seated conditions. It was the very fact of finding, among the specimens sliced from this locality, 20 miles from the edge of the granite, what appeared to be a by no means deep-seated type of granophyre with normal micropegmatite, that led me to re-examine the spot with care the next time I travelled by.

General Conclusions. The phenomena, which I am afraid are only scantily and imperfectly described above, are in some respects closely similar to those which Professor Judd recorded [1] in certain cases which seemed to him to prove the secondary origin of micropegmatite and the growth of crystals in rocks after their solidification. Thus the cloudy central parts of the micropegmatite masses which he observed

[1] Q.J.G.S., May, 1889, pp. 175–86.



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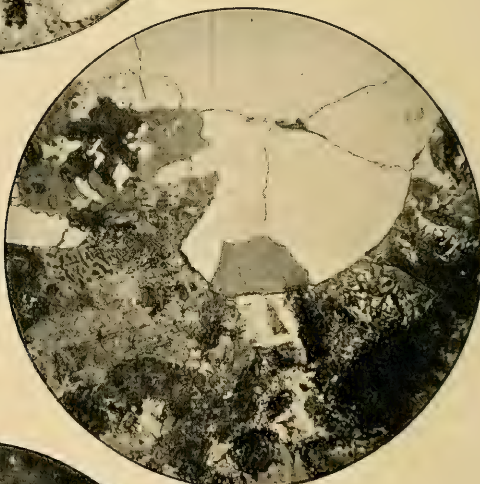
[1703.] Modified Dolerite, with xenocrysts. Kahlele's. × 20 diam.



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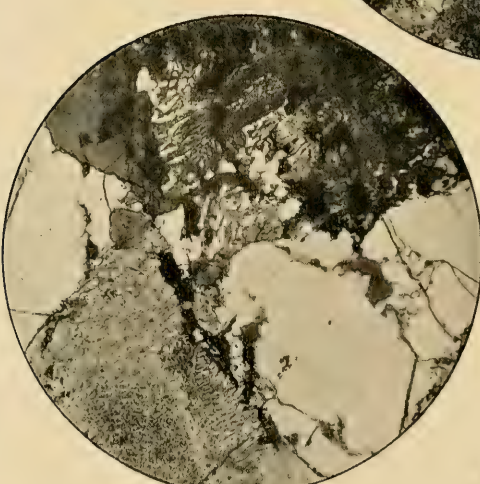
[1704.] Composite Granophyre. Kahlele's. × 20 diam.



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[1705.] Composite Granophyre. Kahlele's. × 20 diam.

Basic Dykes, Rhodesia.

are here well seen, as they are in a number of rocks which may be described as 'porphyrites', e.g. that of Groby, in Leicestershire. In the present case we have, however, clear field and microscopic evidence that they represent the surviving portions of crystals which have had their exteriors melted or corroded. The outgrowths are therefore, as Judd correctly surmised, of the nature of secondary enlargements long after the consolidation of the original nucleus. Where his suggestion was at fault was in regarding the regrowth as having taken place at the expense of a non-crystalline ground-mass. The outgrowths that we have been discussing are clearly due to the recrystallization under the influence of heat of the exterior portions of the original crystals, together in some cases with materials due to reactions with the surrounding crystals or with introduced substances. It need hardly be pointed out that similar phenomena might naturally be observed in basic dykes intruded among sedimentary rocks,[1] but without the guide to their interpretation furnished by the association of the acid materials with what can here be seen in the field to be obvious granite xenoliths. The light such an observation throws on the occurrences of quartz and micropegmatite among basic rocks, and upon the frequently noted association of gabbro or dolerite with granophyre, is evident. There seems little doubt that it may usually be ascribed to the partial admixture, prior to intrusion, of acid and basic materials, not necessarily from related magmas, or even entirely of igneous origin.

EXPLANATION OF PLATES I AND II.

Fig. 1. Fine-grained dolerite, within a few millimetres of a granite xenolith. Antelope Road, Rhodesia. [1737.]

Fig. 2. Granite xenolith, completely penetrated by material from the dolerite, which surrounds and corrodes every individual crystal. Antelope Road, Rhodesia. [1738.]

Fig. 3. Much modified dolerite from dyke near Kahlele's Old Kraal, Matopos, Rhodesia. [1701.] The ground-mass contains a considerable amount of micropegmatite, too fine to be distinguishable in the figure. The xenolith shown consists of two individuals of oligoclase, with a peculiar cloudy mottled appearance. One of these contains two corrosion cavities filled with rather coarse micropegmatite, their fresh felspar extinguishing with that of the xenocryst.

Fig. 4. This shows quartz and felspar xenoliths in a slightly coarser ground-mass than the previous specimen. An orthite crystal is seen as a dark patch at the edge of the slice next to a felspar xenolith. The smaller dark flakes are biotite. [1703.]

Fig. 5. A large corroded quartz xenocryst is shown surrounded by micropegmatite. The rest of the field is largely micropegmatite, too fine to show well in the figure. [1704.] Nicols crossed.

Fig. 6. This shows both quartz and felspar together with fairly coarse micropegmatite. Note the fringe of finer micropegmatite between the cloudy felspar and the adjacent quartz. [1705.] Nicols crossed.

All the figures are magnified 20 diameters.

[1] Compare G. W. Tyrrell, Geol. Mag., August, 1909, p. 365.

III.—Glacier Motion.

By R. M. Deeley, M. Inst. C.E., F.G.S.

SIR HENRY HOWORTH in his *Ice or Water* deals in considerable detail with the various theories of glacier motion which have been propounded. His works are veritable mines of information concerning the subject of ice and water, and he is everywhere anxious to give all workers credit for the work they have done, to state their theories correctly, and if he should differ from their conclusions to do so in a kindly spirit. Among other theories of glacier motion he refers to the one for which I am responsible. Referring to this theory he says—[1]

"In the *Philosophical Magazine* for 1888 Mr. Deeley propounded what he claimed to be a new theory of glacier motion. In this paper he very rightly says 'that every change of outline suffered by a glacier, if we disregard melting and the small internal changes of bulk produced by pressure, etc., is due to the shear of ice plane over ice plane'. He further says of glacier motion: 'We have, therefore, two kinds of motion—one a bodily slide in a downward direction, and another due to the differential motion of the ice not in contact with the ground.' In order to explain the latter he postulates that constant liquefaction and resolidification is taking place within a glacier by the sun's heat penetrating it and melting certain portions, and inasmuch as a glacier has a tendency to sink in consequence of its gravity, the liquefying of certain portions of its interior will take away the support of the rest and let it sink down.

"This theory is, as Le Conte says, a modification of Professor James Thompson's. It seems to me to be based on a great many unverified premises. In the first place, the notion that sun heat can penetrate ice and melt small cavities in its interior, forming ice flowers (as was shown experimentally by Tyndall), may be true of transparent ice, like lake ice, upon which the experiment was tried, but seems to me to be extremely improbable when applied to a glacier with its broken, often snow-covered, opaque or opalescent crust and surface. Again, this process of the sun's heat penetrating a glacier and forming occasional and sporadic ice flowers in its midst would not account for the continuous flow of the whole glacier, whatever effect it might have in inducing isolated particles to move.

"Thirdly, the theory is based on the notion that glacier ice when it flows is at the melting point, and in fact Mr. Deeley says that it has been experimentally proved that it only moves at this temperature. I altogether traverse the view that anything of the kind has been proved, and the fact that the Alpine, Norwegian, and especially the Greenland glaciers all move in the winter shows it to be untenable. Lastly, and this is conclusive, if the theory were right there would not be a continually increasing differential flow from the base of a glacier to its summit and from its sides towards its centre."

It must be admitted that this is rather a sweeping condemnation of the theory. I venture to maintain, however, that Sir Henry Howorth

[1] *Ice or Water*, p. 391.

has misunderstood my meaning in some cases and in others his conclusions are unsound.

The theory propounded in 1888 is as follows: "Take a plate of steel, say 24 inches long, 3 inches deep, and half an inch thick. Firmly fix one end to a suitable support so that the steel plate shall form a girder with its greatest depth in a vertical position. Then distribute a number of weights along the length of the bar. It at once becomes deflected; that is, shear, *elastic shear*, is produced. . . . We will now drill a row of holes along the plate, and when this has been done, the girder, having been weakened, will be found to have taken a still greater amount of set. Still further increase the set by drilling several rows of holes. So far all the operations have been possible ones; but I must now draw upon the imagination somewhat, and perform operations which cannot be carried out in practice. Take the material removed from the numerous perforations in the plate, and replace it so that the plate becomes whole again. It is evident that though again solid, only that metal which formed part of the original perforated plate is in a state of strain, that portion filling the holes taking no share of the load. We will again drill a number of holes, this time in the spaces between the older perforations, and another increase will take place in the deflection of the plate. A strain will also be put upon the metal in the first series of holes bored, and, in addition, a greatly increased strain thrown upon what remains of the original plate. By repeating the operation the girder could be deformed to any desired extent, and, if necessary, such a violent strain thrown upon any one point that *local rupture* would ensue."

I also illustrated the theory by pointing out that the liquid cavities produced in ice by the sun's rays would have a similar effect upon the ice. I never, however, suggested or imagined that the few small cavities near the surface of the glacier which could be formed by the sun's heat were the cause of glacier motion, nor did I suggest, as far as I can remember, that a glacier would not move if the temperature were below the freezing-point. This seems to have been assumed because I refer to the "efficacy of *liquefaction* and *recongelation* to produce glacier motion".

Sir Henry Howorth also refers to a paper communicated by me to the Geological Magazine for 1895. In this paper it is made clear that liquefaction and recongelation are regarded as *molecular phenomena.* In the case of a non-viscous solid the molecules or atoms may be regarded as linked to each other in such a way that their motions, due to the heat of the mass, never sever the linking. It may be that when the body is strained sufficiently the vibrations of the molecules do cause a severance of the molecular attachments; but other attachments are immediately formed and the body is permanently altered in form without fracture. In other words the substance is a plastic one and can only be permanently deformed when the stress exceeds a certain figure. In the case of a viscous body the molecular linking is being constantly broken here and there by the vibrations of the molecules. Each link broken acts like the drilling of the hole in the steel plate and leads to a change of form; for the freed molecules immediately form new and less strained linkages. The higher the temperature the greater will be the number of links broken in a given time and the more rapid will be the distortion; also the greater the stress the greater will be the distortion in the breaking of each link. It does not follow that the breaking of the molecular links will only take place at the freezing-point. It is generally believed that the higher the temperature of the body the more energetic is the motion of the average molecule or atom. Even at the melting-point some of the atoms move slowly and others rapidly, and as the temperature falls there are still molecules moving with sufficient rapidity to cause a breakage of the linkages. This conception of the cause of viscosity also explains the partial recovery of form a stressed viscous substance undergoes when the load is removed. The highly strained but unbroken linkages, on the removal of the external stress, produce an immediate elastic recovery and also a slower recovery as the strains are relieved by the constant breaking of molecular attachments.

It is clear that glacier ice is not a viscous substance in the sense that water, pitch, or alcohol are; for a crystal of ice can only be caused to shear viscously in a direction at right angles to the optic axis. In this case it would appear that the atomic or molecular linkages are broken by the vibrations in one plane only. A mass of ice built up of a number of crystalline granules, as is glacier ice, would not flow viscously if it possessed this viscous peculiarity only, for as the optic axes are in all directions they would lock each other and prevent motion. But it is certain that the molecules at the interfaces of the crystalline granules are constantly forming new linkages, for some granules are increasing in size whilst others are decreasing, there being a constant transfer of molecules from granule to granule. It is to this interchange of molecules between granule and granule that the peculiar viscosity of glacier ice is primarily due. When the stress producing flow is small the granules are of various irregular shapes and sizes and the rate of distortion is small. When the stresses are great, however, the tendency is for the interfaces of the granules to assume the form of shear planes, the granules then slowly sliding over each other without actual *fractures* being produced. The granules, however, are sheared also without fracture, and the coarseness of the granular structure thereby reduced. No doubt the effective viscosity of glacier ice depends largely upon the size and shape of the ice granules.[1] Some calculations I made seemed to prove this. At any rate the difference in the viscosity of the ice of several glaciers seemed to be much greater than could be accounted for by errors in the data.

I will now refer to Sir Henry Howorth's most conclusive argument. He says: "Lastly, and this is conclusive, if the theory were right there would not be a continually increasing differential flow from the base of a glacier to its summit and from its sides towards its centre." As a matter of fact there is *not* an *increasing differential* flow from the base to the summit and from the side to the centre. The rate of distortion is greater at the sides and bottom than it is at the upper

[1] Proc. Roy. Soc., 1908, p. 250.

surface and middle.[1] This I have shown in some detail in a previous communication. Sir Henry Howorth may mean that if my theory were correct the centre would not move more rapidly than the sides and bottom. This would, however, I venture to think, be an erroneous conclusion to draw; for the rate of distortion would depend upon the magnitude of the stress producing shear and also upon the number of the 'linkages' broken in any given time. The act of breaking a link is equivalent to the liquefaction of the molecule and the reattachment to recongelation. The maximum shearing stress, and, therefore, the maximum rate of distortion, is at the bottom of the glacier, and the force producing it is measured by the total downward component of gravity. Half-way between the base and the summit the shearing stress is one-half that at the base, whilst at the summit, on the surface of the ice, it is *nil* and there is no differential motion.

I am sure Sir Henry Howorth will excuse my pointing out that he has been led into a mathematical error by some means or other; for if he were correct my theory would be discredited.

IV.—Note on a Landslip in the Isle of Wight.

By R. H. Chandler.

THE accompanying sketch is from a photograph taken in April, 1906, of a series of landslips just east of Chilton Chine, near Brixton, on the south coast of the Isle of Wight. The cliff, which is

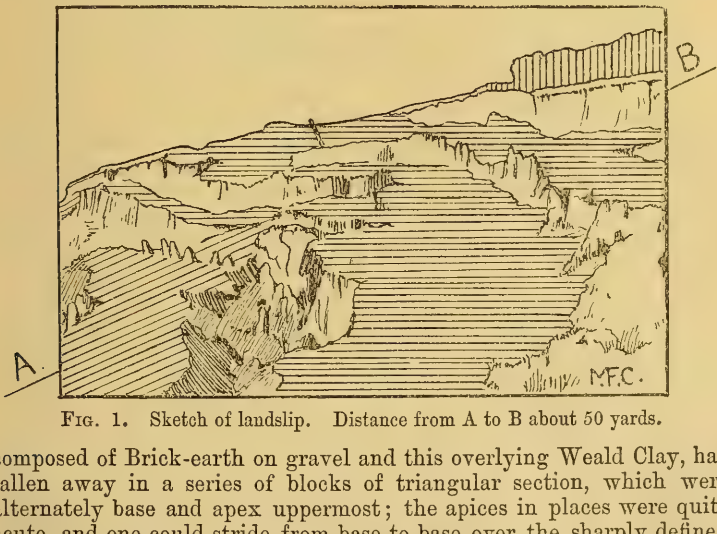


Fig. 1. Sketch of landslip. Distance from A to B about 50 yards.

composed of Brick-earth on gravel and this overlying Weald Clay, had fallen away in a series of blocks of triangular section, which were alternately base and apex uppermost; the apices in places were quite acute, and one could stride from base to base over the sharply defined apex of a clay triangle. The bases of these triangles were the grassed surface, and the apices of toughened and slickensided Brick-earth

[1] Geol. Mag., 1895, p. 408.

which stood up, perhaps, 4 feet beyond the grass; where the apex would naturally have been higher it was usually broken away and crumbled down. There were spaces between the blocks large enough for a horse to fall down and as much as 15 feet deep, at which depth the talus blocked the view. These spaces were overhung by the triangle that stood on its apex, so that the surface contour of my section is correct. At the time the photograph was taken the landslide

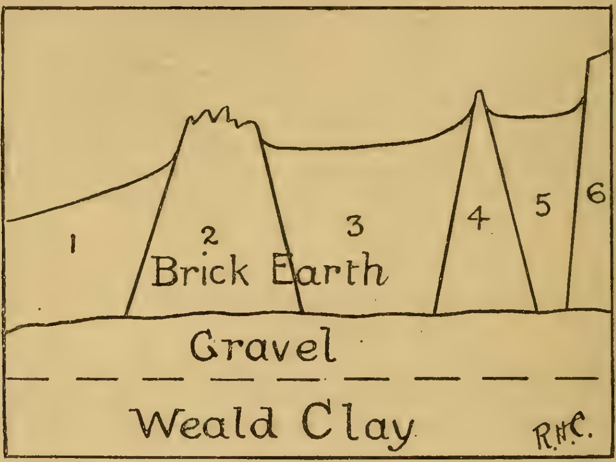


FIG. 2. Probable section along the line AB showing the relative positions of the beds. No scale.

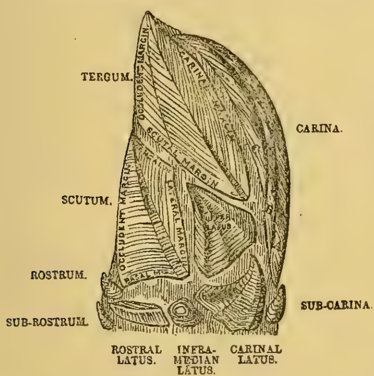
was quite new, that is, small pieces of clay were falling from the overhanging faces and the fractures of grass and clay looked perfectly fresh. Possibly it had only occurred a few hours previously.

The cause of the landslide seems fairly evident, for water percolates through the gravel (on top of the Weald Clay) at a little above the beach level, and this undermines the overlying Brick-earth, besides which the Weald Clay is removed by marine erosion. What appears to have happened in the section here figured may be something like this: for some reason or other the mass of Brick-earth Nos. 1, 2, 3, 4, and 5 became undermined and broke away from No. 6 (which is the normal and undisturbed position of the Brick-earth). The shock of this settlement shook off the block No. 1 as a 'free surface'. Block No. 1 settled down and impinged upon the lower corner of No. 2, which caused the separation of 2 from 3. No. 3 was thus left unsupported and undercut, which caused it to separate from No. 4. No. 3 settled down and separated No. 4 from No. 5 (as 1 separated 2 from 3). The lower parts of these blocks would settle down into the gravel and water, which would render them more easily movable, and the wedges would gradually tend to drive the detached masses seawards.

V.—Some Cirripedes from the Chalk of Salisbury, Wilts.

By Thomas H. Withers, F.G.S.

ALTHOUGH the remains of pedunculated Cirripedes are comparatively rare in the Chalk of England, especially in its lower zones, one can, by careful collecting extended over a number of years, get together a fair series of the detached valves of the capitulum. Thus a very fine series of Cirripede remains has been accumulated by Dr. H. P. Blackmore, F.G.S., from the upper zones of the Chalk near Salisbury. This collection, which, through the kindness of Dr. Blackmore, I have lately had the opportunity of examining, is especially rich in the valves of *Scalpellum fossula*, Darwin, and *S. maximum* (J. de C. Sowerby). It is, of course, only on extremely rare occasions that the valves of the capitulum are found associated, but Dr. Blackmore has been fortunate enough to obtain part of the



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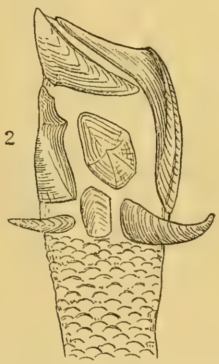


Fig. 1. Restoration of *Scalpellum fossula*, Darwin. (After Darwin.) To show position of valves, and the more primitive types of carina and scutum in which the umbo is apical, and the growth of the valves consequently directed downwards. Senonian: Norwich.

Fig. 2. Restoration of *Scalpellum magnum*, Darwin. (After Darwin.) To show the more advanced types of carina and scutum in which the umbo is subcentral, and the growth of the valves directed in opposite directions. Coralline Crag: England.

capitulum of a form probably referable to *Pollicipes glaber* (F. A. Roemer), a few associated valves of S. *maximum*, and a really beautiful example of *S. fossula* with all the valves of the capitulum in position, as well as a few of the calcified plates of the peduncle. These specimens I hope to be able to describe and figure at some future time.

The present paper contains descriptions of two species of *Scalpellum*, of which one is new, one new species of *Pollicipes*, and one of *Loricula*, all in the collection of Dr. Blackmore. Two of these, *Scalpellum Darwinianum*, Bosquet, and *Loricula expansa*, sp. nov., are of great interest from both a stratigraphical and phylogenetic standpoint.

In the earlier and more primitive forms of *Scalpellum*, the umbo of two of the typical valves of the capitulum (the carina and scutum) is apical, and the growth of the valves is consequently in one direction.

S. tuberculatum, Darwin, constitutes a further advance, for in this form the umbo of the scutum is in a sub-central position, the umbo of the carina being still apical. In the more advanced forms the carina as well as the scutum has the umbo in a central or sub-central position, and the growth of the valves proceeds in two opposite directions. As yet, only one Cretaceous species in which either the carina or scutum has this advanced type of growth has been recorded with certainty from England, namely *S. tuberculatum*. This species was collected by the late William Harris from the Chalk detritus of Charing, Kent, but unfortunately its exact age is doubtful.

The occurrence of *S. Darwinianum*, Bosquet, is therefore of great interest as being the first record of an English species in which the umbo of the carina is sub-central, and the growth consequently in two directions. The species has been found by Dr. Blackmore in the zones of *Actinocamax quadratus* and of *Belemnitella mucronata*.

Including those described in this paper, there have been nearly forty species of *Scalpellum* described from British and foreign Cretaceous rocks. Of these, only five have either the carina or scutum, or both, with the growth proceeding in two opposite directions; namely, *Scalpellum tuberculatum*, Darwin, *S. Darwinianum*, Bosquet, from the Chalk of this country; and *S. Beisseli*, Bosquet & Müller, *S. Darwinianum*, Bosquet, *S. Hagenovium*, Bosquet, and *S. radiatum*, Bosquet, from the Upper Senonian and Maestrichtian of Holland and Belgium, and other foreign localities.

The significance of this will be seen when it is noted that a much larger proportion of the Tertiary species have this double direction of growth, and among the recent species the percentage is still higher.

Loricula expansa, sp. nov., is also of much interest, since it represents a further development in the scutum, the umbo of which is situated in a much more central position than in the other forms of *Loricula*. Unfortunately the scutum is the only valve known, but owing to its great importance it is thought advisable to describe it, especially as it is represented by five examples.

It is therefore apparent that there is a close connexion between the geological age of the forms and the position of the umbo in certain valves of the capitulum, and this feature is consequently of great phylogenetic importance.

To facilitate the interpretation of the isolated valves here described, figures are given in the text in which the valves of the capitulum are in position. (See Figs. 1, 2, p. 21, and Fig. 7, p. 28.)

Scalpellum Darwinianum, Bosquet. Figs. 3, 4.

1854. *Scalpellum Darwinianum*, J. Bosquet, Les Crust. Foss. du Terrain Crétacé du Duché de Limbourg, p. 46, pl. iii, figs. 6–12.
1854. *S. Darwinianum*, C. R. Darwin, Ray Soc. Monogr. Sub-class Cirripedia, Synopsis et Index Systematicus, p. 631.
1880. *S. Darwinianum*, Th. Marsson, Mittheil. naturw. Vereine von Neu-Vorpommern und Rügen, Jahrg. xii, p. 4, pl. i, fig. 1.
1888. *S. Darwinianum*, A. Peron, Bull. Soc. Sci. Yonne, vol. xli, p. 270, pl. iii, figs. 1–4, 1887.

This most interesting species, hitherto unrecorded from the English Chalk, is represented in Dr. Blackmore's collection by five carinæ and one right tergum. Three of the carinæ are very small and measure only about 2 mm. in length, the fourth measures 8 mm., and the fifth (Fig. 3), although slightly broken at each extremity, measures 12·6 mm. in length. The right tergum is slightly broken at the apex and basal angle, the portion remaining measuring 9·5 mm. in length and 3·6 mm. at its widest part.

Distribution.—Upper Senonian: *Actinocamax quadratus*-zone, East Harnham, near Salisbury; *Belemnitella mucronata*-zone, Alderbury and Clarendon, near Salisbury, Wilts; *Actinocamax quadratus*-zone, Reims, France; *Belemnitella-mucronata*-zone, Isle of Rügen. Upper Senonian and Maestrichtian: St. Pierre, Duchy of Limbourg, Holland. Upper Senonian: Frère, near Tongres. Maestrichtian: Sichen, Belgium.

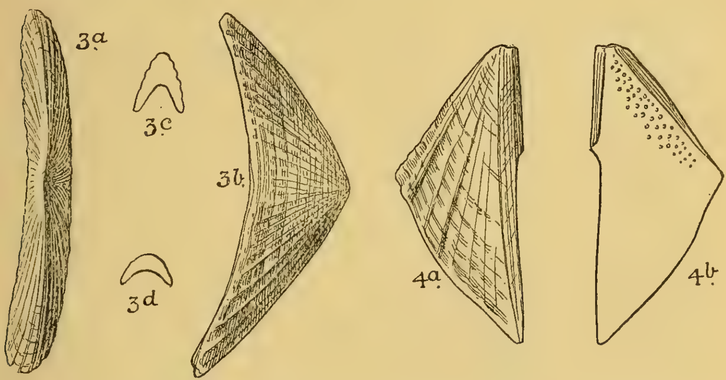


FIG. 3*a*. *Scalpellum Darwinianum*, J. Bosquet. × 4 diam. External view of carina, with umbo in sub-central position. Upper Senonian, *Belemnitella mucronata*-zone: Alderbury, near Salisbury, Wilts.
,, 3*b*. Id. Side view.
,, 3*c*. Id. Transverse section at one-third from apex.
,, 3*d*. Id. Transverse section at one-third from base.
,, 4*a*. Id. External view of right tergum. × 4 diam.
,, 4*b*. Id. Inner surface of same showing series of tubercles.

Description of Carina. Carina (Fig. 3) not quite symmetrical, being markedly convex on the left side and concave on the right, abruptly bent near the middle, umbo almost central, situated slightly nearer to the upper extremity of the valve; form linear, the upper and lower regions forming an angle of about 112°; inner margin curved; the lower region of the valve a little wider than the upper; sides of valve sharply inflected and almost flat. The roof of the carina is very narrow above the umbo, and from the umbo downwards is somewhat wider. The valve is not divided off into tectum, parietes, and intraparietes, but these parts are fused. The whole exterior surface is ornamented with raised ridges, which radiate from the umbo, and are much coarser on the roof of the carina than on its sides. These ridges are crossed by finer raised ridges, which follow the outline of the valve, giving the surface a cancellated appearance. Inner surface of valve deeply concave.

Tergum. A right tergum (Fig. 4) found at the same locality and horizon as the carina, agrees so well with the homologous valve associated with the carina of *S. Darwinianum* figured by Bosquet (1854) that I propose to describe it here as belonging to it.

Tergum obtusely angular in general outline, narrow, about two and a half times as long as wide, ornamented with several irregular, raised longitudinal ridges. Apex and basal angle pointed. Carinal margin slightly extended for its upper third beyond the rest of the margin, and forming a narrow, almost rectangularly inflected margin, which when looked at from above is hardly discernible, so that the whole carinal margin appears to be nearly straight. Scutal margin slightly sinuous, a little longer than the occludent margin, with which it forms an obtuse angle. An obscure ridge divides the valve unequally from the apex to the basal angle. Carinal portion very narrow, wider in its upper third, and ornamented with two or three extremely fine longitudinal lines. Occludent portion at its maximum much wider than the carinal portion, and with raised ridges radiating from the apex. Of these ridges, two are much coarser than the others, one extending from the apex to about the middle of the scutal margin, and the other, which is much more raised, running near and almost parallel to the occludent margin. Inner surface of valve shows more plainly the abrupt extension of the upper third of the carinal margin. From the base of the projecting portion to the apex, and along its edge, a narrow portion of the valve is marked with fine oblique lines, which are also seen for the same extent on the opposite edge of the valve. For about a third of the breadth of the valve, parallel to the occludent margin and extending nearly its length, the inner surface of the valve is marked with a series of small tubercles.

Remarks. J. Bosquet (1854), in his original description of the carina of *S. Darwinianum*, states that the tecta or roof-parts of the carina are smoothed and flattened, the rest of the valve being ornamented with fine ribs. In the English examples, on the contrary, the whole of the valve is covered with raised ridges, these being more strongly marked on the tecta, and this seems to be the case also with the carina from the *Actinocamax quadratus*-zone of Reims represented in the figure given by A. Peron (1888). The tergum described above also presents slight differences, the most important being the position of the ridge that divides the valve into carinal and occludent portions. Bosquet figures this as situated almost in the middle of the valve, while in the English example it is much nearer the carinal margin. Both terga agree in the presence of a narrow tract of tubercles on their inner surfaces, a character which is not known in any other Cretaceous species of *Scalpellum*. The function of these tubercles is evidently closely connected with the attachment of the membrane which held together the plates of the capitulum. These differences, however, are not sufficient to justify founding a new species, since the smoothness of the tecta mentioned by Bosquet in his diagnosis of the species, and emphasized in his figure of the carina, may be due to the imperfect or different mode of preservation of the Maestricht specimens. On the other hand, it may represent a different stage in the development, and in this connexion it may be noted that the English and French forms come from a slightly lower horizon.

The carinæ of this species are very variable, the ribs in some specimens being much finer and more numerous than in others. This is also the case with two carinæ from the Maestrichtian of St. Pierre, Duchy of Limbourg, which were acquired from the author of the species, J. Bosquet, for the British Museum (Natural History), registered (I 13604, I 13605). The smaller specimen (I 13605) is ornamented with very fine and numerous ridges, the tecta not being very smooth; the larger specimen (I 13604) has much coarser and fewer ridges, and the tecta are much smoother. In the carina (Fig. 3) from Alderbury, the valve is convex on the left side and concave on the right, a feature which can be seen in the larger valve (I 13604). This, however, is not the case in the smaller valve

(I 13605), or in the other English specimens, neither does it appear to be so in the carina figured by Bosquet (1854) or that by Peron (1888).

SCALPELLUM LONGISSIMUM, sp. nov. Fig. 5.

Diagnosis. Tergum long, narrow, about three and a half times as long as wide, widest part of valve near the base, scutal margin proportionally very narrow, and formed by two straight lines which make an angle of about 140°. Surface of valve smooth.

Material. A right and a left tergum, both complete, and a portion of a right tergum. The complete right tergum has been crushed and the pieces slightly displaced, but the left tergum, although it has been broken, has been so reset that it shows its original shape. It measures 24·3 mm. in length, and its greatest width is 7 mm.

Holotype.—The left tergum (Fig. 5).

Horizon and Locality. Upper Senonian, *Actinocamax quadratus*-zone: East Harnham, near Salisbury, Wilts.

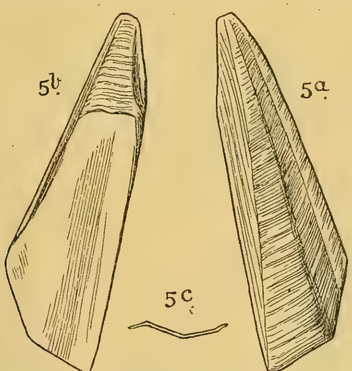


FIG. 5*a*. *Scalpellum longissimum*, Withers, sp. nov. External view of left tergum. × 2 diam. Upper Senonian, *Actinocamax quadratus*-zone: East Harnham, near Salisbury, Wilts.
,, 5*b*. Id. Inner surface of same, showing portion of valve near apex marked with fine transverse lines.
,, 5*c*. Id. Section across middle of same.

Description of Holotype. Tergum divided into two unequal portions by a well-defined ridge extending from the apex to the basal angle; the carinal portion is extremely narrow and emerges from the basal angle, widening very slowly until it reaches about three-quarters the length of the valve, and then rapidly narrows until it reaches the apex, thus forming an obtuse angle about one-fourth from the apex; the occludent portion in its widest part, which is at the angle formed by the occludent and scutal margins, is about three times the width of the widest part of the carinal portion (i.e. one-fourth from the apex); scutal margin formed of two almost equal straight lines making an obtuse angle. Occludent portion sharply bent downwards from the carinal portion, and on reaching the line from the apex to the angle of the scutal margin, becomes flattened and forms a wide flat groove or depression. This is bounded by a slip of about the same width, which rises sharply up from the depression and forms a rounded border to the occludent margin. On the carinal portion the growth-lines are very obliquely upturned, and run nearly parallel to the lower part of the carinal margin, and on the occludent portion they are more prominent than on the carinal portion, and follow the outline of the scutal margin. On the inner surface there is an extremely narrow portion of the valve along the inner occludent margin, marked with very oblique lines, and a considerable part of the apex, marked with transverse lines, probably indicating the extent to which the valve projected freely.

Comparison with other Species. These terga are quite unlike any valves either of *Pollicipes* or *Scalpellum* with which I am acquainted. The terga which apparently come nearest to them are those of *Scalpellum maximum* (J. de C. Sowerby) and its varieties. These, however, differ much from *S. longissimum*, especially in the more pointed and produced basal angle, the pointed apex which is curved towards the carina, and in the general shape of the valves, which are much more curved, and in some specimens almost crescentic.

POLLICIPES FILOSUS, sp. nov. Fig. 6.

Diagnosis. Carina almost straight, transversely rounded, basal margin obtusely V-shaped, with basi-lateral angles somewhat produced, and the whole exterior surface ornamented with fine rounded longitudinal ridges.

Material. Two carinæ. The smaller specimen is not quite complete, but the portion preserved measures 9·3 mm. in length and 2·3 mm. in greatest width. The largest specimen is complete, but somewhat crushed, so that it is impossible to give its accurate breadth. It is 22·6 mm. long, and measured about 5 or 6 mm. in breadth.

Holotype. The larger and complete carina (Fig. 6).

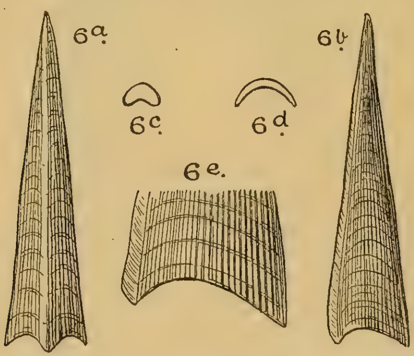


FIG. 6*a*. *Pollicipes filosus*, Withers, sp. nov. External view of carina. × 2 diam. Upper Senonian, *Belemnitella mucronata*-zone: Redlynch, near Salisbury, Wilts.
,, 6*b*. Id. Side view.
,, 6*c*. Id. Transverse section at one-third from apex.
,, 6*d*. Id. Transverse section at one-third from base.
,, 6*e*. Id. Enlarged view of external surface near base, showing direction of growth-lines, and the increased number of longitudinal ridges near its inner margin. × 4 diam.

Horizon and Locality. Upper Senonian, *Belemnitella mucronata*-zone: Clarendon and Redlynch, near Salisbury, Wilts.

Description of Holotype. Carina almost straight, long, narrow, widening very gradually from the apex, extremely convex transversely, obscurely carinate, inner margin straight; apex sharply pointed; basal margin obtusely V-shaped, with basi-lateral angles produced into spur-like processes; parietes narrow and slightly inflected. Valve extremely thin near its base, gradually becoming thicker towards the apex; and probably projected freely to some extent. The lines of growth are directed upwards from the middle of the carina, where they are obtusely V-shaped, and then curve downwards to the inner margin of the parietes, whence they are abruptly and obliquely inclined towards the apex. The whole exterior surface is ornamented with fine, rounded, longitudinal ridges, which are finer and more numerous near the inner margin of the valve.[1]

Comparison with other Species. The carina described by Darwin as *Pollicipes striatus* (1851, p. 70, pl. iv, fig. 5) agrees with *P. filosus* in being longitudinally ridged, but disagrees in being plainly carinate, and the longitudinal ridges are not so fine, rounded, or so closely set. *P. filosus* is also strongly convex in transverse section, while *P. striatus* is flatly arched and almost triangular. *P. filosus* may be compared with the carina of *P. glaber*, F. A. Roemer (1841, p. 104, pl. xvi, fig. 11), and the two carinæ doubtfully referred by Darwin (1851, p. 58) to his *P. Angelini*. These latter valves, originally in the Fitch Collection, are now preserved in the Norwich Museum. Both in *P. glaber* and *P. Angelini* the direction of the growth-lines almost exactly agree with *P. filosus*, and consequently the three species have their basi-lateral angles produced into short spurs. They differ from *P. filosus* in being much wider and shorter, plainly sub-carinated, flatly arched transversely, and in their surface not being covered with numerous fine longitudinal ridges. One of the two carinæ referred by Darwin to his *P. Angelini* agrees more closely than the other with *P. filosus* in the direction of the growth-lines, and this specimen has a few flattened longitudinal ridges near its apex; but the rest of the valve is smooth, and differs in the characters mentioned above.

Loricula expansa, sp. nov. Fig. 8.

Diagnosis. Scutum smooth, slightly longer than wide, with the umbo situated nearly in the middle of the occludent margin, and a single well-marked groove extending from the umbo to near the top of the tergo-lateral margin.

Material. Two left and three right scuta, all nearly perfect. The complete left scutum, which is the largest, measures 7 mm. in length and 5 mm. in breadth.

Holotype. The left scutum (Fig. 8).

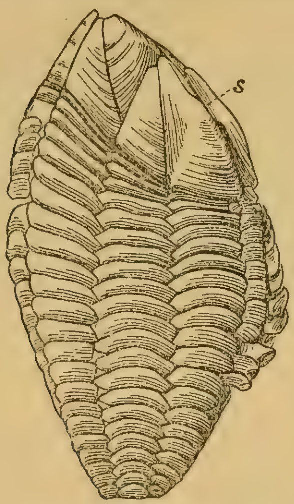
Horizon and Locality. Upper Senonian, *Actinocamax quadratus*-zone: East Harnham, near Salisbury, Wilts.

Description of Holotype. Left scutum sub-triangular in general outline, extremely thin, slightly convex; occludent margin slightly rounded in its upper part, dropping rapidly down in an almost straight line to the rostral angle, the lower part of the occludent margin being almost at right angles to the basal margin; the upper part of the occludent margin suddenly rises up from a groove, which extends from the umbo to near the top of the tergo-lateral margin; basal margin straight, almost at right

[1] Since writing the above description, I have been shown by Dr. H. Woodward some Cirripede remains from the collection of Mr. R. M. Brydone, F.G.S. Among the specimens are two portions of carinæ of *Pollicipes filosus*, together with a tergum which, judging from its ornamentation, also belongs to *P. filosus*. These specimens came from the *Belemnitella mucronata*-zone of Portsdown, Hants. One of the portions of carinæ represents the upper half of a valve about the same size as that of the holotype. It agrees exactly in its external form and ornamentation, but the upper portion is much more solid, and the character of its inner surface shows that the valve must have freely projected for about one-fourth of its length.

angles to the tergo-lateral margin; tergo-lateral margin nearly straight, slightly rounded at the top towards the occludent margin; umbo nearly in the middle of the occludent margin, slightly nearer the rostral angle. The finely-marked and closely-set growth-lines follow the outline of the basal and tergo-lateral margins, and on reaching the groove, which runs almost parallel to the upper part of the occludent margin, bend towards the margin. The inner surface of the valve along the inner occludent margin rises up in a thickened band, being much thicker nearer the middle, and forming a raised ridge overhanging the thinner part of the valve, thus making a pit or depression for the attachment of the adductor scutorum. This thickened ridge, especially near the middle, is marked with fine oblique lines.

Remarks, and Comparison with other Species. Since the umbo in the scuta described above is sub-central, and the growth consequently in



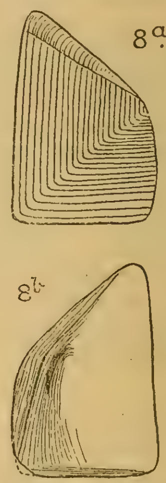


Fig. 7. *Loricula Darwini*, H. Woodward. Reproduced here to show position of scutum (*s*), in which the umbo is situated nearest the apex, and the upper part of the valve much attenuated. × 2 diam. Turonian, *Rhynchonella cuvieri*-zone: Cuxton, near Rochester, Kent.

Fig. 8*a*. *Loricula expansa*, Withers, sp. nov. External view of left scutum, with umbo in sub-central position. × 4 diam. Upper Senonian, *Actinocamax quadratus*-zone: East Harnham, near Salisbury, Wilts.

,, 8*b*. Id. Inner view of same, showing pit for adductor muscle.

two opposite directions, it was at first thought that the plates belonged to an undescribed form of *Scalpellum* allied to *S. tuberculatum*, Darwin (1851, p. 43, pl. i, fig. 10), and *S. cretæ*[1] (Steenstrup) (1837, p. 359; 1839, p. 399, pl. v, figs. 1–3), in which the umbo is also sub-central, and not apical as in the more primitive fossil species of *Scalpellum*. They differed much, however, from those species in the general shape and ornamentation of the valves, and on comparing them with the corresponding valves in *Loricula* it was at once apparent that they agreed more closely with that genus. Examination of the scutum in *Loricula pulchella*, G. B. Sowerby (1843, p. 260, figs. 1, 2), and

[1] Good descriptions and figures of the valves of this species are given by Darwin (1851, p. 45, pl. i, fig. 11).

L. Darwini, H. Woodward (1908, p. 493, fig. 1), shows that, as in our specimens, the tergo-lateral and basal margins are nearly straight and almost at right angles to each other, differing much in this respect from the scutal valves of *Scalpellum*, to which the genus *Loricula* is most nearly related. Further, in *Loricula* the occludent margin of the scutum is convex, the umbo is sub-central, and the valves extremely thin and slightly convex, characters also observed in the scuta described above. The inner occludent margin of the scutum is much thickened in *Loricula*, especially in the region of the umbo, and this is also the case in the valves before us, leaving no doubt that they are rightly ascribed to the genus *Loricula*.

Darwin (1851, p. 84) hazarded the opinion that in *Loricula* the lateral valves of the capitulum must have been present on both sides, and in support of this view Dr. H. Woodward (1908, p. 495) pointed out that in the specimen of *L. Darwini* figured by him, and in the example of *L. pulchella*, var. *minor*, figured by Fritsch & Kafka (1887, p. 2, pl. i, fig. 2), the inner margin of the under scutum could be seen projecting from beneath the occludent margin of the upper scutum. Decisive proof of the paired nature of the lateral capitular valves in this genus had, however, already been given by Whiteaves, for in the holotype of his *L. canadensis* (1889, p. 190, pl. xxvi, figs. 4, 4*a*) the upper lateral series of capitulum plates have been either partially or completely broken away, showing underneath the inner surfaces of the scutum, tergum, carinal latus, and the upper or middle latus. The under row of sub-rostral (or sub-scutal) plates of the peduncle can also be seen projecting from beneath the upper row in the figured example of *L. Darwini*.

So far, then, there is conclusive proof that the three lateral plates of the capitulum, as well as the row of sub-scutal plates of the peduncle, were present on both sides of *Loricula*; but whether the three central rows of peduncular plates are also present on the under side is still doubtful. In fact, after removing the chalk from beneath one of the three specimens of *L. Darwini* studied by him, Dr. H. Woodward found that the three principal (central) rows of the elongate scales of the peduncle were absent. He then suggested that they were not developed upon the under side of the peduncle, but that the animal was fixed to the Ammonite shell, to which *Loricula* has always been found attached, along the margins formed by the under row of the carinal and sub-rostral (or sub-scutal) valves. Bearing on this question is a fact which does not appear to have been attended to. Among the specimens of *L. pulchella* figured by Fritsch & Kafka (1887) and those of *L. Darwini* studied by H. Woodward (1908), some show the right side uppermost, with the scutum on the left hand, and others the left side uppermost, with the scutum on the right hand. Although it appears probable from this that the whole of the peduncular valves were developed on both sides of *Loricula*, it is by no means conclusive proof, since it may be quite accidental as to which side of the animal was developed uppermost, in the same way that certain lobsters have the 'crushing chela' developed on the right side and others on the left.

L. expansa differs from all other species of *Loricula*, including

L. lævissima, Zittel (1884, p. 589, fig. 4), from the Upper Chalk of Dülmen, Westphalia, in that the scutum is much broader in proportion to its length, and in the umbo being situated in a much more central position. *L. Darwini*, H. Woodward, differs from *L. expansa* in the upper portion of the valve being much narrower and attenuated, and in the smaller convexity of the occludent margin. Moreover, the umbo is situated nearer the apex, and is much more prominent: a feature of phylogenetic importance.

In the primitive forms of *Loricula*, the umbo of the scutum must have been apical and the growth of the valve directed downwards. *L. Darwini*, H. Woodward, from the Turonian (*Rhynchonella cuvieri*-zone), is a further advance in which the growth of the scutum has been directed both downwards and upwards beyond the umbo, which is situated a short distance from the apex. The umbo is still prominent, and the upper portion of the valve is much attenuated. *L. expansa*, which comes from the Senonian (*Actinocamax quadratus*-zone), a much higher horizon, represents a still further stage in the development of the scutum, as might be expected. In this form the umbo is in a more central position, slightly nearer the base of the valve, and since the portion of the valve above the umbo is developed to a greater extent and is wider than in *L. Darwini* the umbo is consequently inconspicuous.

In conclusion, I have to express my indebtedness to Dr. H. P. Blackmore for allowing me to describe these specimens, and to thank Dr. F. A. Bather, Dr. W. T. Calman, and Mr. C. P. Chatwin for help in connexion with this paper.

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Zittel, K. A. (1884). "Bemerkungen über einige fossile Lepaditen aus dem lithographischen Schiefer und der oberen Kreide": Sitz. d. math. phys. Classe d. k. b. Akad. der Wissensch. zu München, xiv, Hft. iv, pp. 577–89, text-figs. 1–5.

VI.—On the Origin of the Cylindrical Cavities in certain Sandstones of the Fayûm, Egypt.

By H. J. Llewellyn Beadnell, F.G.S.

In an article published in a recent number of this journal,[1] Dr. Henry Woodward discusses the origin of the curious cylindrical cavities which occur in such profusion in certain concretionary blocks of sandstone and on exposed rock-surfaces at two distinct levels in one or two localities in the Fayûm depression. These perforated rocks, first noted by Schweinfurth, were examined by me some ten years ago and referred to as "apparently the work of marine boring mollusca" in my memoir on the region in question.[2] Both Dr. Schweinfurth and I had considerable misgivings in regarding the cavities in question as shell-borings, but in my case, and I believe in his also, this explanation appeared to involve fewer difficulties than any other which suggested itself.

Dr. Woodward, after comparing these cylindrical cavities with certain reed-casts found by Mr. J. E. S. Moore on the shores of Lakes Kivu and Tanganyika, pronounces that the perforations in the rocks of the Fayûm are identical in character with the latter, and concludes that they represent the casts of reeds which grew on the shores of the existing lake, the Birket el Qurûn, or on those of its more extensive predecessor, Lake Moeris.

Knowing Dr. Woodward's achievements in the interpretation of obscure fossil remains—witness his solution of the problem of the Sherringham flint pebble—I hesitate to question his verdict in the case of the Fayûm perforations. His explanation would, indeed, be more than welcome, as it would to some extent remove a difficulty arising from the assumption that these cavities are the work of marine boring mollusca, i.e. the necessity for admitting a considerable submergence of the region in Pliocene or post-Pliocene times.[3]

[1] "On some supposed *Pholas*-borings from the Shores of Birket el Qurûn, the ancient Lake Moeris, of the Fayûm, Egypt": Geol. Mag., September, 1910, pp. 398–402.

[2] "The Topography and Geology of the Fayûm Province of Egypt": Survey Department, Cairo, 1905.

[3] Submergence of the region in Middle Pliocene times to a level of between 60 and 70 metres (above present sea-level) is, I think, satisfactorily established on the evidence of the marine shell-bearing deposits of Sidmant, etc. Submergence to a level of 170–80 metres rests at present on somewhat unsatisfactory grounds, mainly (*a*) the supposed shell-borings at about 112 metres, and (*b*) the remarkable gravel terraces extending up to 180 metres above present sea-level.

Were I able to compare specimens of the Lake Kivu reed-casts and the Fayûm perforations, and had I at hand the original notes which I made when surveying the Fayûm, I might be in a position to accept or disprove Dr. Woodward's explanation without further consideration. As it is, I venture to ask the following questions:—

1. Would actual casts of the stems of reeds similar to those found at the present day on the shores of the lakes in question show close resemblance to the Fayûm perforations? Do the latter exhibit traces of the longitudinal striæ or of the segment-rings which occur at intervals along the stems? Both striæ and rings are, if I recollect rightly, very well marked in the semi-fossil siliceous reeds which are occasionally found on (presumably weathered out of) the ancient high-level deposits of the Fayûm lake.

2. Would not a true cast of a portion of a reed be of almost constant diameter throughout, and is it not a fact that the individual perforations in the Fayûm rocks vary considerably in diameter from point to point, showing concentrically arranged alternating ridges and hollows? My recollection that such is the case seems confirmed by the illustration in the paper, though the appearance may, of course, only be due to the concentric lines used for shading.

3. Do the reeds taper gently at the root as do those of the cavities of which the terminations are visible? And do the latter show any traces of the rootlets?

4. Assuming the above points can be satisfactorily disposed of, does not the theory that the Fayûm perforations represent reed-casts absolutely depend on the truth of the assumption that the concretionary and other blocks of sandstone, etc. (in which the perforations occur), actually represent portions of the material which accumulated round the bases of the reeds, while the latter were growing on the margins of the modern Birket el Qurûn or its predecessor Lake Moeris?

5. What, may I ask, is the evidence for such assumption? My impression is that the concretionary and other sandstones and sandy limestones in which the perforations occur belong to definite bands of the marine Middle Eocene formation. They are certainly so referred to in my memoir (see pp. 43, 71–3), and I am not aware of any evidence having since been met with which would necessitate a modification of this opinion. Dr. Andrews' statement "that the huge concretions, or globular masses of sandstone—honeycombed with vertical borings—represent in all probability the actual bases where these reeds formerly grew",[1] requires substantiation before it can be accepted as disposing of and replacing the above-mentioned view.

Without in any way criticizing Dr. Woodward's conclusion that the Fayûm perforations are not the work of boring molluscs, I submit that it is essential, before seeking to establish their identity with reed-casts, to bring forward satisfactory evidence that the rocks in which the perforations occur are of lacustrine origin, and not weathered-out or exposed portions of the marine strata of the Middle Eocene formation.

[1] See p. 401 of Dr. Woodward's article.

REVIEWS.

I.—Outlines of Geologic History, with especial reference to North America. By Bailey Willis and Rollin D. Salisbury. 8vo; pp. viii, 306, with numerous text-illustrations. Chicago University Press and Cambridge (England) University Press, 1910.

IN the Geological Magazine for July, 1906 (p. 328), we drew attention to the very interesting *History of American Geology* then published by Mr. G. P. Merrill. That volume dealt with the gradual growth of knowledge, since 1785, historically and biographically.

The present volume consists of "A series of essays involving a discussion of geologic correlation presented before Section E of the American Association for the Advancement of Science in Baltimore, December, 1908". The symposium was organized by Mr. Willis, who also prepared the instructive series of palæographic maps which are interspersed in the text; and the volume has been edited by Professor Salisbury. It may be added that the several chapters have appeared in the *Journal of Geology*, and are now bound together for the convenience of geological students; and that the volume will be welcomed as containing the results of much research and important philosophic suggestions with regard to the distribution of life in the strata and the principles of correlation.

Mr. C. R. Van Hise, in the opening chapter, deals with the principles of classification, with the nature, sequence, and continuity of formations, and with unconformities and deformations. He considers that pre-Cambrian rocks may be grouped into Archæan and Algonkian, and that these two major divisions are general, if not worldwide: the Archæan dominantly igneous, largely volcanic and submarine; the Algonkian mainly sedimentary, and laid down when "essentially the present conditions prevailed on the earth". The subdivisions of the Archæan into Laurentian and Keewatin are purely lithological, the one consisting mainly of plutonic acid rocks, the other largely of volcanic basic rocks.

Professor Frank D. Adams follows with an essay on the basis of pre-Cambrian classification, urging that a threefold division is needed. He applies the terms Eo-, Meso-, and Neo-Proterozoic, the first to the Archæan (of Van Hise), the second to Lower and Middle Huronian, and the third to Upper Huronian or Animikie–Nastapoka and Keweenawan–Athabasca. These three major periods are in the opinion of Professor Adams separated by great unconformities or epochs of diastrophism—epochs which afford "a basis of correlation of great value and importance". Mr. Van Hise rightly objects to a 'zoic' classification, which is unsupported by fossil evidence.

In the next essay Mr. C. D. Walcott discusses the evolution of early Palæozoic faunas in relation to their environment, and points out that although the traces of pre-Cambrian life are very meagre, they "are sufficient to indicate that the development of life was well advanced long before Cambrian time began". Thus the characteristic fossil of the known pre-Cambrian fauna "is *Beltina danai*, a Crustacean probably more highly organized than the trilobite. The associated annelid trails indicate that this phase of the fauna was also strongly developed. Stratigraphically, this fragment of what must have been a large fauna occurs over 9,000 feet beneath an unconformity at the base of the upper portion of the Lower Cambrian in northern Montana".

In support of his contention that the Cambrian faunas were profoundly influenced by their environment, Mr. Walcott observes that in the restricted waters of the Lower Cambrian the known Brachiopods (of the entire world) were represented by twenty genera and seventy-five species, whereas in the expanding seas of the Middle Cambrian thirty-one genera and 243 species are known to have existed.

The physical and faunal evolution of North America during Ordovician, Silurian, and early Devonian time is dealt with by Professor A. W. Grabau; and he is followed by Mr. Stuart Weller, who discusses the correlation of the Middle and Upper Devonian and the Mississippian faunas of North America. In these articles the distribution of the faunas, the invasions of forms from other areas, and their dependence on sedimentary conditions are discussed; and Professor Grabau describes the effects of 'regressive overlap' or 'off-lap' when the area of sedimentation was lessening. Mr. Weller remarks that "All questions in correlation become progressively more complex as the territory occupied by the faunas under consideration is extended"—their history, in fact, has to be considered biologically, geographically, and geologically.

Mr. G. H. Girty writes on the Upper Carboniferous or Pennsylvanian, and in the course of his essay observes that "The Upper Carboniferous faunas of Western North America have a facies markedly different from those of the eastern part, and are closely comparable to the corresponding faunas of Asia and Eastern Europe". The author doubts whether the Kansas Permian and the Russian Permian were contemporaneous; the weight of evidence, as presented by invertebrate palæontology, appears to him to favour the view of the pre-Permian age of the Kansas deposits.

Mr. David White discusses the evidence of the Upper Palæozoic floras, their succession and range, and the changes brought about by great diastrophic movements. Thus the extensive orogenic movements in Europe stimulated the evolution of the Permian flora, whereas "in the Appalachian trough, where environment was but little affected by orogeny, and where sedimentation was uninterrupted, there is only gradual change, many of the Stephanian [Carboniferous] types persisting far up in the Dunkard formation" or Permian of South-Western Pennsylvania. The plants do not appear to differ in kind, whether found in the grey limestone-bearing strata or in the red rocks that are nearly devoid of limestones.

The faunal relations of the early air-breathing vertebrates form the subject of an essay by Dr. S. W. Williston, who discusses the evidence of continued intermigration of land animals between the eastern and western continents. Then follow a series of articles on the succession and distribution of later Mesozoic Invertebrate faunas in North America, by Mr. T. W. Stanton; on the succession and range of Mesozoic and Tertiary floras, by Mr. F. H. Knowlton; and on the conditions governing the evolution and distribution of Tertiary faunas, by Mr. W. H. Dall. Marine, brackish-water, and freshwater strata are dealt with, and the evidence of the assemblages of fossils that existed under different physical and climatic conditions is discussed in reference to their value in indicating geological time.

In an account of the environment of the Tertiary faunas of the Pacific coast of the United States Mr. Ralph Arnold points out that "Many of the movements occurring throughout the Tertiary were of local extent, and, for that reason, correlation on a basis of diastrophism, unsupported by palæontologic evidence, is extremely hazardous".

The correlation of the Cenozoic through its mammalian life is discussed by Professor H. F. Osborn, who remarks that "The sea borders of the United States may be correlated with each other and with those of Eurasia in Cenozoic times through their invertebrate life, but for the vast interior of the American continent we must depend chiefly upon the mammals and in a less degree upon the reptiles, fishes, insects, and plants".

The Physical Geography of the Pleistocene with reference to the correlation of the formations, is the subject of an interesting article by Professor Salisbury. Mr. D. T. Macdougal then deals with the speculative subject of the Origination of Self-generating Matter and the influence of aridity upon its evolutionary development. Finally Professor T. C. Chamberlin explains Diastrophism as the ultimate basis of Correlation.

The absence of an index to this volume is unfortunate.

II.—Principles of Chemical Geology. By James Vincent Elsden, D.Sc., F.G.S. London: Whittaker & Co., 1910.

THE title of this work will recall to the mind of geologists the ponderous volumes of Bischof, which in their day held a high place in geological literature. Dr. Elsden's book, however, is a small, compact volume, and deals mainly with aspects of chemistry that were not recognized in Bischof's time. It is an exposition of the results attained by physical chemists in so far as they are directly applicable to problems of mineralogy and geology. The subject is treated from the standpoint of the equilibrium law formulated by Le Chatelier in 1884, and in successive chapters such questions as viscosity, diffusion, vapour pressures, eutectics, and crystallization of solid solutions are dealt with. The treatment is necessarily brief, yet the exposition is clear and the numerous references to original papers make the book useful to advanced students who desire a further acquaintance with the subject.

The services that physical chemistry has rendered to geology in the hands of masters of the science such as Van't Hoff, Ostwald, Tammann, and Roozeboom are very great. In every way the best example of the value of this line of investigation is the work of Van't Hoff and his pupils on the Stassfurt salt deposits. There is good reason to hope that in the future such questions as the origin and structure of igneous rocks will in the simpler cases at any rate receive physico-chemical solutions. Much work must be done before that day comes, but we have already an earnest of the results in the work of Vogt and the chemists of the Carnegie Institution in Washington. It is becoming almost a necessary part of the education of every geologist that he should be acquainted with the main principles of physical chemistry as applied to geology.

Dr. Elsden's experience as a teacher and his original work as a petrologist have specially qualified him for this task. The book condenses into a small space information gleaned from a wide variety of sources. It is thoroughly up to date, and the only errors we have noticed in it are a few printers' errors. It may be strongly recommended to all students not only for the accuracy of its contents but also for the fairness and judicial caution with which it handles such thorny subjects as the origin of magmas by diffusion and the sequence of crystallization in igneous rocks.

J. S. F.

III.—The Geology of New Zealand: an Introduction to the Historical, Structural, and Economic Geology. By James Park, Professor of Mining and Mining Geology in the University of Otago, etc. 8vo; pp. xx, 484, with geological map, 22 full-page plates and maps, and 140 text-illustrations. London: Whitcombe and Tombs, Ltd., 1910.

WITH the ever-increasing volume of geological literature we welcome a summary of what is known regarding the main features in the geology of New Zealand, especially as the work is written by one who has taken an active part in the geological survey of the country and in the practical applications of the science. The very useful bibliography given by the author extends over 56 pages, and in preparing it he acknowledges his indebtedness to Dr. Wilckens of Bonn University.

New Zealand possesses representatives of nearly all the main geological systems, although the author is not quite right when he says that the record is "more complete and varied" than that of Australia. The Devonian system, at any rate, is not admitted by him into the New Zealand table of sedimentary formations. Some of the gneisses and crystalline schists of the Maniototo Series were regarded by Hutton as pre-Cambrian or Archæan, but the rocks which are admittedly the oldest in New Zealand are grouped by the author as Cambrian, as they are closely associated with graptolite-bearing rocks of Ordovician age. Again, the equivalents of the Oligocene are not recognized in the New Zealand series.

In the classification of the strata "it is generally conceded by New Zealand geologists that the chief formations should be distinguished by Maori names", and these are applied by the author both to the systems and subdivisions, from the Cambrian to the Pliocene, the European time-divisions being likewise indicated. The progressive succession in the forms of life corresponds generally with that of Europe, but "obviously there may exist homotaxial parallelism without synchronal agreement". Thus it is stated, on the authority of Hutton, "that several genera of marine mollusca that appear in the Eocene of Australia did not reach New Zealand until the Miocene and Pliocene periods." But how came *Cardium striatulum*, Sow., to be recorded from the older Pliocene (Awatere) Series? Here we may mention that we miss a reference in the body of the work to the sponge-remains, described by Dr. G. J. Hinde and Mr. W. M. Holmes, from the Lower Tertiary strata near Oamaru, although the title of their paper is given in the Bibliography.

Silurian rocks are represented by the Wangapeka Series, which has yielded, according to McKay, *Calymene Blumenbachii*, *Homalonotus Knightii*, and other fossils. The Te Anau Series, next in succession, rests unconformably on the older rocks, and is grouped with the Carboniferous, although it contains "no internal evidence of its age", but it is followed by fossiliferous rocks of the Carboniferous period. In upward succession the various formations and their fossils are described, together with the intrusive and volcanic rocks associated with them. In the Hokonui system, Permian to Jurassic, there are no traces of contemporary volcanic action, but "the volcanic activity which began in the Upper Cretaceous epoch has continued with little cessation up to the present day". It is interesting to note the occurrence of greensands and of chalky limestone and chert in the Cretaceous rocks. The Eocene and Miocene formations are the principal coal-bearing strata, the former yielding anthracite, bituminous, brown, and pitch coals, and the latter yielding brown coals. Coal is also found in Jurassic and Cretaceous strata. The author estimates that the available amount of coal (excluding seams less than 2 feet thick) is about one thousand million tons, and that it is likely to be exhausted in 140 years or less. He deals also with the other mineral products—gold, iron-ore, building-stones, etc.—and remarks that "the conservation of its mineral resources will soon be the chief care of every civilized country".

The faults and physical changes which have effected the area of New Zealand are duly described. A full and interesting account is given of the Pleistocene glaciation, during which the invading ice-sheet exceeded 7,000 feet in thickness. Raised beaches, old lake beaches, post-glacial fans, and other phenomena are likewise described.

Brief accounts are given of the Recent period, which is divided into the Moriorian (Neolithic) and Dinornian, with the *Dinornis* and other recently extinct birds. Brief also are the descriptions of the geysers and hot and boiling springs of water and mud; both hot and cold mineral springs are regarded as possessing valuable curative properties.

The illustrations comprise some very good pictorial views and photographs of fossils, many sketches of fossils, some diagrammatic, and longitudinal sections. There is also a capital index. We notice a few misprints: thus *Amusium* is spelt throughout *Amussium*.

IV.—Causal Geology. By Professor E. H. L. Schwarz, A.R.C.S., F.G.S. Blakie and Son, Ltd.

This work treats of the origin of the earth, of the source of the earth's rocks, the atmosphere and oceans, and of the processes and agents which induce changes on the earth's surface. It may be said to be a vindication and elaboration of the planetismal hypothesis of Chamberlin. The author has evidently given much attention to the problems of causative geology, and, in addition to the results of personal observation, he has collected a formidable array of facts and statistical data as evidence of the various hypotheses he propounds or theories he supports. At the same time, the subject at his hands has received somewhat unequal treatment, and his reasoning is not always easy to follow.

The book is one which reflects the working of a scientific mind, but it is felt that unconsciously the author has now and then correlated the obvious with the obscure, and placed uncontroverted facts side by side, and on the same plane, with mere conjectures. Some of his deductions thus seem hardly warranted, but apart from the controversial portion of the work, which in itself is of much interest, the book is full of scientific facts and observations from cover to cover.

It is well printed, and the illustrations, of which there are thirty-two text-figures and several plates, are exceedingly clear and well reproduced.

H. H. T.

V.—The British Carboniferous Orthotetinæ. By Ivor Thomas, B.Sc., Ph.D. Memoirs of the Geological Survey of Great Britain: Palæontology, Vol. I, Part II, pp. 83–134, and Plate XIII. 4to. London, 1910. Price 2*s*.

In the Geological Magazine for February, 1909 (p. 76), attention was drawn to the publication of Dr. B. N. Peach's *Monograph on the Higher Crustacea of the Carboniferous Rocks of Scotland.* The present memoir or monograph is paged in continuation of the volume of which that work was the first part.

The sub-family Orthotetinæ belong to the Brachiopod family of Strophomenidæ, and the aim of the author is to determine more particularly the British genera and species that belong to the sub-family. The genera now recognized are *Meekella*, *Orthotetes*, *Derbyia*, *Schellwienella*, *Schuchertella*, *Streptorhynchus*, and *Geyerella*, all except the last-named (which is a Permian genus) occurring in British strata. *Schellwienella* is a new genus now described by the author. The genotype is *Spirifera crenistria*, Phill., a familiar species, which like many another has passed through various phases of nomenclature, at one time known as *Streptorhynchus crenistria*, at another as *Orthotetes crenistria.* The author, however, shows that the form figured by Davidson as *Streptorhynchus crenistria* is a *Schuchertella*; and as he remarks, "It is inevitable that the application of more critical methods and the acquirement of fresh evidence, both morphological and stratigraphical, should lead, from time to time, to revisions of classification and consequently, to some extent, of nomenclature." The difficulty to the geologist is that the more the genera and species are split up the less agreement there appears to be about them, and that in course of time palæontologists are likely to bury themselves in a mass of detail. The present work is indeed drawn up on the lines of the most progressive palæontology, by an earnest and skilled worker, whose care is beyond praise and whose conclusions are probably as sound as could be. The more interesting stratigraphical results may be given in the author's words: "Regarding the general distribution of the genera it may, therefore, be said that *Schellwienella* is found throughout the Carboniferous Limestone and in the Millstone Grit of this country and is known on the Continent from the Lower and Middle Devonian rocks. The so-called '*Orthotetes*' *umbraculum* of the British Devonian deposits probably also belongs to this genus, but is usually so badly preserved as to render diagnosis uncertain. *Schuchertella* is found in the Carboniferous Limestone and Millstone Grit, while *Derbyia* occurs in the Carboniferous Limestone, especially in the upper part, and in the Millstone Grit. *Orthotetes* is only known in this country from the Coal-measures. *Meekella* has been found in the upper deposits of the Carboniferous Limestone and in the Millstone Grit, and *Strepto-rhynchus* is known chiefly from the Permian rocks, but occurs also in the higher beds of the Carboniferous Limestone." An excellent plate of figures is given.

VI.—Guide to the Geological Model of Ingleborough and District. By Aubrey Strahan, M.A., Sc.D., F.R.S. Memoirs of the Geological Survey, England and Wales. 8vo; pp. iv, 17, with 2 plates and 1 text-figure. 1910. Price 4*d*.

In the Geological Magazine for June, 1906 (p. 275), we drew attention to Dr. Strahan's *Guide to the Geological Model of the Isle of Purbeck*, an area comparatively simple in plan, but full of interesting and instructive features. In the Ingleborough district the author has to deal, not only with far bolder features, but with unconformities and disturbances of great magnitude. The lower grounds are occupied by a portion of the Ingleton Coal-field, the uplands by Carboniferous Limestone and Yoredale rocks, with the grand outlier of Millstone Grit which forms the summit of Ingleborough. The uplands are trenched by certain broad valleys that exhibit Silurian, Ordovician, and older rocks (the 'Ingleton Series'), which may be of pre-Cambrian age. The general relations between the physical features and geology are strikingly shown in the two plates. One depicts the model in plain form without names; the other is an excellent colour-printed geological map of the area, without Glacial drift. The Craven fault, which is reckoned to cause a displacement of more than 5,000 feet near Ingleton, and some other lines of disturbance, are clearly indicated by the physical features.

The structure of the ground is also illustrated by a longitudinal section across Ingleborough and the Ingleton Coal-field. This would have been more ready of comparison with the map had it been drawn from south-west to north-east, instead of in the opposite direction.

The author gives a concise account of the succession of the strata, and of the disturbances and erosion whereby the present structure and physical features have been built up and sculptured, attention being drawn to the interesting glacial phenomena, the caves, swallow-holes, and underground water-channels in the Carboniferous Limestone.

VII.—Brief Notices.

1. Maryland Geological Survey.—The eighth volume of general reports issued (1909) under the superintendence of Dr. W. Bullock Clark, State Geologist, like the former volumes, is admirably printed and illustrated. The subjects of road materials and road-construction are further dealt with, and views are given of roads before and after improvement under State aid. There is a detailed report on the mineral industries, accompanied by a useful table of the geological formations of the State and their economic products; there is also a special report on the limestones with reference to their use in the manufacture of lime and cement.

2. Natural Resources of Maryland.—The first Report of the Conservation Commission of Maryland for 1908–9 is of much interest and importance. The object of the Commission is the conservation of the natural resources of the country, and among matters to which attention is drawn are the reclamation of great areas of swamp; the acquisition on the part of the State of the deforested areas around the head-waters of streams that afford the chief water-supplies; the preservation of special areas of picturesque scenery; and the prevention of waste in the development of the mineral resources. Professor H. Conwentz (as noted in the Geological Magazine for September, 1909, p. 429) has urged the desirability of taking more care of natural objects of interest, and our Coal Commissions have warned us not to be negligent of our limited supplies of coal. Maryland now supplies an example of organized effort to deal generally and practically with natural phenomena and resources.

3. Geology of the Country around Sheffield.—A very useful sketch of the geology, by Messrs. B. Hobson, Cosmo Johns, and C. Bradshaw, was issued in the Handbook and Guide for the British Association at the recent Sheffield meeting. Special attention is given to the fossils of the Carboniferous rocks and the Pleistocene mammalia, and there is a good colour-printed geological map.

4. Cornish Palæozoic Fossils.—Mr. J. H. Collins has prepared Addenda to the working list of Cornish fossils (Trans. Roy. Geol. Soc. Cornwall, xiii, pp. 385–427, 1910), his previous list having been drawn up eighteen years ago.

5. Rhodesia Museum, Bulawayo.—The eighth annual report of the Museum for 1909 contains an account of the gold-bearing rocks and a list of the minerals of the country, drawn up by Mr. A. E. V. Zealley, who last year succeeded Mr. F. P. Mennell as Geologist and Curator.

6. Mineral Production of India.—Vol. xxxix of the Records of the Geological Survey of India (1910) contains a Quinquennial Review of the Mineral Production during the years 1904 to 1908, by Sir Thomas H. Holland and Dr. L. Leigh Fermor. Comparing the average values

of the minerals produced during the period with that of the previous five years, an increase in value is noted in every case except rubies. The average increase, which amounts to more than $2\frac{1}{2}$ million pounds, is due mainly to progress in developing coal, petroleum, salt, gold, manganese-ore, and mica. Attention has been given also to the development of bauxite, copper-ore, and lead-silver ores.

7. Rivers.—In a paper brought before the Cotteswold Naturalists' Club, but regarded as too controversial for publication in the Proceedings, and now issued separately (Gloucester, 1910, price 1*s*.), Mr. T. S. Ellis has dealt with "The Winding Course of the River Wye". Believing that an area uplifted from the sea would have an irregular surface and that the streams would form a network, some meeting again after being diverted, some branching off to unite with other streams, he rejects the idea of primary consequent streams—we presume in the sense of their having an entirely independent origin. His observations lead him to conclude that the Upper Wye formerly continued its course through the Talgarth Valley to the Usk, and that tidal influence played an important part in forming the course of the river during the gradual elevation of the land.

8. River Action.—Mr. F. M. Burton, author of *The Shaping of Lindsey by the Trent* (1907), has issued another little work entitled *The Witham and the Ancaster 'Gap': a Study of River Action* (1910). In this the formation of the Ancaster Gap is attributed to a former course of the River Devon, which now flows into the Trent west of Newark. The possible influence of the ice of the Glacial Period in impounding the drainage and causing the erosion of the gap, as advocated by Mr. Harmer, is not discussed.

9. Geological Map of Cape Colony.—We have received two sheets of the colour-printed Geological Survey map on the scale of $3\frac{3}{4}$ miles to 1 inch, by Dr. A. W. Rogers and Mr. A. L. Du Toit. Sheet No. 40 includes the country around Marydale, traversed by the Orange River; and Sheet 32, which adjoins on the south, takes in the country around Van Wyk's Vlei. In the northern area the quartzites of the Kheis Series and large tracts of granite that intrude into them, dominate the country; in the southern area the Karroo System with dolerite intrusions extends over the greater part. Longitudinal geological sections are printed on the margins of the maps.

10. Geological Survey of Western Australia.—Bulletin No. 33 (1909) contains the results of "Geological Investigations in the Gascoyne, Ashburton, and West Pilbara Goldfields", by Mr. A. Gibb Maitland, Government Geologist, with Petrological Notes by Mr. J. Allan Thomson. It is well illustrated by 13 geological maps and 65 figures, comprising plans, sections, and pictorial views. The mineral resources, in addition to gold, include stream-tin, lead and copper ores, and mica. Artesian wells in the Gascoyne district yield more than eleven million gallons of water daily from seventeen bore-holes that range from 850 to 3,011 feet in depth. The rocks described by Mr. Thomson include schists, quartzites, cherty carbonates, marble, dolomites, serpentine, gabbro, amphibolite, dolerite, and granite.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

November 23, 1910.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Effects of Secular Oscillation in Egypt during the Eocene and Cretaceous Periods." By William Fraser Hume, D.Sc., F.G.S., Director of the Geological Survey of Egypt.

The main points considered in the paper are:—

A (1). There is evidence of the gradual advance of the Cretaceous sea from north or north-east over Egypt during Upper Cretaceous times. Four stages in this advance are indicated by the geographical distribution of the Cretaceous deposits, and especially by the relations of the detrital Nubian Sandstone formation to the organic Cretaceous limestones. The four phases are: (*a*) A North Egyptian type, in which the Nubian Sandstone entirely underlies fossiliferous beds of Cenomanian (Lower Chalk) age. This extends across Egypt from Sinai to Baharia Oasis. (*b*) A Wadi Qena type, developed near the head of the valley of that name, characterized by the alternation of Nubian Sandstone with fossiliferous Cretaceous beds. Three main divisions of Nubian Sandstone are recognized—one at the base of the Campanian (in the Upper Chalk), another above the Turonian (Middle Chalk), and a third below the Cenomanian beds, but closely related and passing into them. The recognition of the type was one of the most interesting results of this year's expedition in the Eastern Desert. (*c*) A Central Egyptian or Hammama type, in which the Nubian Sandstone forms the greater portion of the Cretaceous Series, only the Danian and Campanian beds being fossiliferous limestones or shales. This section is divisible into an Eastern facies, in which *Pecten* Marls are a special feature; and an Oasis facies, characterized by a fauna of small Gasteropoda, etc., in the shales, and species of *Echinocorys*, crinoids, and *Terebratulina gracilis*, etc., in a white chalk indicating a close affinity to the White Chalk of Northern Europe. These two divisions have been linked together by the discovery of the shales with the typical Oasis and small Gasteropod, etc., fauna in the same series as the *Pecten* Marls, and overlying them. The Campanian beds are characterized by the presence of phosphatic fish-beds. (*d*) A South Egyptian type has close resemblances to the Central Egyptian; but in the Campanian the phosphatic beds are inconspicuous, and a fauna of sea-urchins was discovered consisting mainly of new species.

The results of the Eastern Desert expedition of 1910 in Wadi Qena bear the strongest testimony to the Cretaceous age of the Nubian Sandstone.

B (2). As regards the transition from the Cretaceous to the Eocene, the following points are noted: The existence of two types of strata at the base of the Eocene: the first, the Luxor type, being fossiliferous, mainly characterized by the presence of *Operculina libyca*, etc., and largely developed in the Western Desert; the second, or Qena type, being on the other hand entirely unfossiliferous, and composed of white limestones lithologically similar to the Danian white limestone below them, but structurally different. These beds, directly underlying fossiliferous Eocene strata, are honeycombed, closely jointed, and especially subject to erosion by water, the regularly bedded Cretaceous strata differing in these respects.

(3) A suggestion is made that these variations may be due to fold effects produced while the land was gaining on the sea at the beginning of Eocene times, the Qena limestones being remade Cretaceous material.

(4) Whereas in Southern Egypt Lower Eocene strata directly overlie the Danian strata, in Northern Egypt very marked unconformities exist between the Middle Eocene and the Cretaceous beds.

(5) The main palæontological differences between the Cretaceous and the Eocene are recorded, the principal feature being the sudden incoming of the large Foraminifera *Nummulites* and *Operculina*; in both formations oysters and sea-urchins are dominant, Brachiopoda being almost entirely absent.

C. In this section the distribution, zonation, and variation of the Eocene Series is considered, the main points being—

(6) The apparent uniformity of the fossiliferous Lower Eocene strata wherever developed.

(7) The lack of uniformity in the Middle Eocene strata, only the lowest zone, that of *Nummulites gizehensis*, being of wide distribution. The nature of the Eocene beds between Baharia Oasis and the depressions of Moela and the Fayum are described, zoned, and compared with the Middle Eocene in other parts of Egypt, the importance of the uppermost zone, the *Gisortia* Limestone, being emphasized.

(8) The influence of the gain of land over sea is traced through the Upper Moqattam Beds (with their increase in detrital materials and disappearance of *Nummulites*) and the Calcareous Grits overlying them to the quartz-chert gravels forming the desert west of Cairo and the Fayum, which are usually considered to be Oligocene, and mark the final stages in the growth of the Oligocene continent.

The Cretaceous Period in Egypt is, therefore, one marked by the gradual gain of sea over land; during the Eocene, on the contrary, land appears to have been steadily gaining on the sea, probably accompanied by gentle fold movements which account for the minor differences in the nature of the Eocene deposits. At the close of Eocene times and during the Oligocene Epoch the approach of a continental phase is clearly indicated, all the stages in these varied movements being illustrated in the desert regions.

2. "The Origin of the British Trias." By A. R. Horwood. (Communicated by Professor T. G. Bonney, Sc.D., F.R.S., F.G.S.)

It is maintained that, though desert conditions prevailed locally during the Triassic Period in Britain, deposition was brought about solely by the action of water; and the British Trias is a delta-system. For, during Carboniferous, Permian, and Triassic times deposition was mainly in the same area. There is, moreover, a gradual gradation from the Bunter to the Rhætic, from coarse sediments to fine. The Bunter is known to be of fluviatile origin, since Professor Bonney first showed it to be so; and there is a continuity from Lower to Upper Trias, with an unconformity due to the new mode of formation and change in sedimentation. Oscillation and overlapping, which occur in the Trias, are admittedly due to aqueous agency. The Triassic outcrop and the delta area of the River Mississippi are closely similar. The alternations of pebbles and sands, sandstone and marl, etc., are due to those seasonal changes which are characteristic of deltas. Coloration is original, from below upwards, and not coincident with bedding. The thickness of the Bunter is an argument for a subsiding area. The ferruginous types in the Carboniferous, Permian, and Trias are alike due to delta conditions. The Trias is horizontal now, as originally, away from any ancient hills which it covers, and 'radial dip' is merely 'angle of rest'. It is only the skerries, furthermore, that are rippled. Screes, too, occur mainly to the south-west of submerged hills. Sandstones thin out eastward, marls westward, and the skerries are on the hills. The surface features of ancient hills once covered by Trias are quite unaffected; and desert conditions are merely marginal, limited to granitic or syenitic knolls at one horizon, while in the surrounding areas such conditions are absent. Rock-salt and gypsum are also horizontal and continuous in a linear direction. The Keuper gradually merges into the Rhætic phase, and the latter into the Lias. Since the Bunter sediments came from the north-west into the Midlands, so probably did the Upper Trias. Triassic sediments and those of the Nile are similar, but the first have been acted upon chemically, the latter mechanically. Local metamorphic and volcanic rocks may have provided some of the heavier minerals, but as a whole their source was more distant. The flora and fauna can be grouped in provinces around the delta-head of the Trias. These considerations all point to an aqueous mode of sedimentation in a moist and equable climate; and desert conditions only prevailed locally.

December 7, 1910.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

Dr. A. S. Woodward communicated an account of recent excavations in the cavern of La Cotte, St. Brelade's Bay (Jersey), made during the present year by the Jersey Society of Antiquaries. According to the report of Mr. E. T. Nicolle and Mr. J. Sinel, shortly to be published by the Jersey Society, the cave has yielded evidence of human habitation and traces of Pleistocene Mammalia. About a hundred flint implements of the Mousterian type have been obtained, besides part of a molar of *Rhinoceros antiquitatis* and both teeth and antlers of *Rangifer tarandus*. Human remains and teeth of *Bos* have also been examined and determined by Dr. C. W. Andrews and Dr. A. S. Woodward, to whom the whole of the collection of mammalian remains was referred. This being the first discovery of typical Pleistocene Mammalia in the Channel Islands, the Jersey Society hopes to proceed with the excavations as soon as possible.

Dr. A. Strahan, F.R.S., Treas.G.S., delivered a lecture, illustrated by lantern-slides, on the occurrence of recent shelly Boulder-clay and other glacial phenomena in Spitzbergen.

II.—Mineralogical Society.

Anniversary Meeting, *November* 15.—Professor W. J. Lewis, F.R.S., President, in the Chair.

J. H. Collins: Further Notes on Wood-tin. It is concluded that wood-tin, which always contains a good deal of iron oxide and is much more opaque and more soluble than ordinary cassiterite, is the chalcedonic form, the shot-tin having had a concretionary and the botryoidal form a stalagmitic origin.—J. M. Coon: On the Alteration of the Felspar of Granites to China-clay. The action has taken place from within the earth towards the surface below the underground water-level, the water outlets being generally indicated by schorl and quartz veins. The nature of the products of the alteration was discussed.—Professor W. J. Lewis: On Wiltshireite, a new mineral from the Binnenthal. The crystals were tin-white in colour, russet-brown when tarnished; small, but aggregated in parallel position; with monoclinic symmetry, $a:b:c = 1\cdot587:1:1\cdot070:\beta = 100^\circ\ 44'$. Paucity of material prevented a chemical analysis, but no doubt it is a lead sulpharsenite. Named after the late Rev. Professor T. Wiltshire.—Arthur Russell: On a new locality of Phenakite in Cornwall. A single specimen showing numerous colourless, prismatic crystals of phenakite was found by him at Wheal Gorland, Gwennap, Cornwall, this year. The specimen obtained from a lode at present worked for wolfram and traversing the granite close to its junction with the killas.

CORRESPONDENCE.

BRONTEUS HALLI.

Sir,—You may like to note that the type-specimen of *Bronteus Halli*, H. Woodward (Geol. Mag., Sept. 1910, p. 407), has just been presented by the Directors of the North Devon Athenæum to the Trustees of the British Museum. It is being placed on exhibition in the Geological Department, and is registered I. 13645. The cast, which came to this Museum as part of the Townshend M. Hall Collection in 1886, was a wax squeeze of the holotype, and has been registered I. 2184. Mr. Hall had, however, previously presented two plaster casts, one of the holotype, one of its counterpart which, as stated in the paper, appears to have disappeared from the J. E. Lee Collection. These casts have been registered respectively, I. 13646, I. 13647.

Now neither the original specimen, collected in 1875, nor any of these casts bears on its label any indication that the specimen came from the Lower Middle Devonian, as stated in the legend to Fig. 1 (Geol. Mag., Sept. 1910, p. 408). "Middle Devonian" no doubt it is, and "Lower Middle Devonian" it may be; but one would like to have the evidence for this definite statement.

F. A. Bather.

October 11, 1910.

YORKSHIRE GEOLOGISTS AND RECORDERS.

Sir,—Having a fair knowledge of the names of fossil invertebrata I thought I would have a try at the prize-competition suggested by "Recorder" in your October number (p. 479). Here is my 'spot':—

Psil-onotus.	*Cor-*	*Ast*-ieria.	*Echi*-oceras.
Cal-	*Agas*-sizia.	*Nicro-* . . .	*Der*-oceras.
Schlot-heimia.	*Arn*-ioceras.	*Ambly*-ceras.	*Polym-* . . .
Ver-	*Arie*-tites.	*Oxyn*-otus.	*Upt-* . . . .

I write away from books, but the names seem to be those of Ammonites, and one is tempted to complete the list by the simple addition of *oceras*; I fear, however, that even so I should not get a place.

As a worker and a recorder myself I have often wondered why some writers should so delight in enigmas; but if the Geological Magazine would start a problem-page for such during the winter months, it might secure fresh subscribers and the wits of the coming generation might be sharpened.

What?

BEMBRIDGE FOSSILS ON CREECHBARROW HILL, ISLE OF PURBECK.

Sir,—I have just lately received from Mr. Keeping a copy of his paper on the finding of "Bembridge Limestone Fossils on Creechbarrow Hill", and asking my opinion on his paper. I cannot entirely agree with his conclusions, for the following reasons:—

1. His section (Geol. Mag., October, 1910, p. 437) appears to be taken from Alum Bay, Isle of Wight, and it seems to me that there is not sufficient space between the Chalk and the top of Creechbarrow for the whole series of beds to fit in.

2. The sand and flints which he regards as "Pleistocene drifts" may be so, but they were seen by the late Mr. Hudleston and myself in a pit (opened under my superintendence) *passing under the limestone*, and referred to by him (see Geol. Mag., 1902, p. 248). This is a point I desire particularly to call attention to.

3. As regards the piece of limestone mentioned by Mr. Keeping as having been picked up by a workman from among the gravel "at a depth of about 13 feet", there is considerable room for doubt, bearing in mind the probability of the piece having rolled down into the pit accidentally. It certainly does not disprove Mr. Hudleston's section showing a layer of flints *beneath the limestone*. The subject is certainly of sufficient interest for some able geologist to take up and investigate independently. Even if the Creechbarrow Limestone fauna and the Bembridge may be identical, they are not necessarily upon the same horizon, and may have existed in Lower Bagshot times. Why not?

A. H. Bloomfield.

Rose Cottages, Grange Road,
Wareham.
October 25, 1910.

THE HIGH-LEVEL GLACIAL DRIFT AND THE LAND-ICE HYPOTHESIS.

Sir,—The prevailing conception with regard to the manner in which the famous high-level shelly gravels have been transported, according to the land-ice hypothesis, may be fairly indicated by the following quotations:—

"It is difficult to understand how the ice could climb out of such a basin as that of the Irish Sea, and ascend such steep slopes as those of the Welsh hills up to a height of at least 1,350 feet." (Sir Archibald Geikie, *Text-Book of Geology*, vol. ii, p. 1319.)

"Even if the thickness of the ice cap over the Dumfries and Kirkcudbright hills had been about 2,500 feet, that, with every allowance for viscosity, would hardly give us a head sufficient to force a layer of ice from the level of the sea-bed to a height of nearly 1,400 feet above it, and at a distance of more than 100 miles." (Professor Bonney, Presidential Address to British Association, Sheffield Meeting, 1910.)

The advocates of the land-ice hypothesis apparently do not resent this rendering of their views. On the other hand, as far as one can judge from their utterances, they seem to regard it as the inevitable statement of their case.

Though in favour of the land-ice view, I find it impossible to believe that a thick ice-sheet can plough up beach material with its front, and climb or rather be pushed bodily up steep and lofty hill slopes to heights exceeding 1,000 feet. On a small scale, with comparatively thin masses of ice and low hummocks, this may be a feasible operation; but if not physically impossible, it is an improbability of a very high order with a thick sheet of ice, when heights of from 500 to 1,500 feet have to be scaled. But is such a view necessary?

Thrusting and shearing are well-recognized factors in ice movement. Contortions accompanied by upward overthrusts have been observed by Chamberlin in the Bowdoin Glacier of Greenland; and in a photographic illustration which he has given of these, some of the fracture-planes are seen to be very oblique ("Glacial Studies in Greenland": Journal of Geology, 1897, p. 235). In this upward overthrust action we have a rational explanation of the manner in which beach material may be raised by land-ice to fairly lofty altitudes.

The tendency of this upward thrust-action would be to translate the bottom ice with its infrozen ground moraine to higher and higher levels as the ice moved onwards; and this tendency would become more marked where the ice-sheet encountered a hill, or had to force its way through a narrowing valley.

Is it not already admitted that the ground moraine can traverse an ice-sheet obliquely and finally reach the surface by this up-thrusting action in the ice; and why should not shells be permitted to reach the surface in this way? Is it not, moreover, by this means, rather than by a simple and bodily lifting of its sole, that a thick ice-sheet heaps itself to some extent against 'nunataks' which oppose its movement? Beyond such comparatively slight heaping of the ice, there appears to be no need to assume, on behalf of the land-ice hypothesis, that there was any bodily elevation of the ice-sheet on the slopes of Moel Tryfaen or the other hills on which the shelly drift occurs.

T. Crook.

OBITUARY.

CHARLES BIRD, B.A., F.G.S.

Born January 20, 1843. Died April 11, 1910.

Mr. Charles Bird, whose death took place in April last at Strood, had been for thirty years Head Master of the Mathematical School in Rochester. At an earlier period, after graduating at the University of London, he was appointed Second Master at the Bradford Grammar School. There he took considerable interest in geology, and communicated to the Proceedings of the Geological Society of the West Riding (1875) a paper "On the Red Beds at the Base of the Carboniferous Limestone in the North-West of England". In 1881 he published *A Short Sketch of the Geology of Yorkshire*. During his long residence at and near Rochester he devoted much attention to the local geology, the fruits of which were published in the *Rochester Naturalist* from 1883, in papers on the Medway muds, the North Downs, and the Water Supply of Hoo. He likewise assisted in conducting excursions of the Geologists' Association to Burham, Aylesford, Frindsbury, and Upnor. He was President of the Rochester Naturalists' Society during four years between 1883 and 1899, and was author of a work on *Elementary Geology* published in 1890 and of *Advanced Geology* issued a few years ago.

WILLIAM HARMON NILES, LL.D.

Born May 18, 1838. Died September 13, 1910.

Mr. W. H. Niles, who had studied under Louis Agassiz, was professor of geology and geography at the Massachusetts Institute of Technology from 1871 to 1902, president of the Boston Natural History Society from 1892 to 1897, and had been head of the department of geology at Wellesley College since 1888.

MISCELLANEOUS.

University of Brussels.—Mons. Maurice Leriche, who has up to the present been "Maître de Conférences" at Lille University, has been appointed Professor of Geology at the University of Brussels. He has lately issued in the Memoirs of the Royal Natural History Museum of Belgium an important monograph, "Les Poissons Oligocènes de la Belgique." Professor Dollo remains at the University as Professor of Palæontology, and will still continue Conservator of the Department of Vertebrates, Living and Fossil, of the Brussels Museum.

University of Oxford.—Dr. Arthur Vaughan has been appointed lecturer in geology at the University of Oxford.

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ASSISTED BY

PROFESSOR J. W. GREGORY, D.Sc., F.R.S., F.G.S.
DR. GEORGE J. HINDE, F.R.S., F.G.S.
SIR THOMAS H. HOLLAND, K.C.I.E., A.R.C.S., D.Sc., F.R.S., F.G.S.
PROFESSOR W. W. WATTS, Sc.D., M.Sc., F.R.S., PRES. GEOL. SOC.
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HORACE B. WOODWARD, F.R.S., F.G.S.

FEBRUARY, 1911.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VIII.

No. II.—FEBRUARY, 1911.

ORIGINAL ARTICLES.

I.—The Mineral Condition of the Calcium Carbonate in Fossil Shells.

By Grenville A. J. Cole, F.G.S., and Otway H. Little, A.R.C.Sc.I., B.A.,
Royal College of Science for Ireland.

A RECENT paper by Mr. A. R. Horwood on "Aragonite in the Middle Lias"[1] raises again the question of the condition of the calcium carbonate in fossil shells. Mr. Horwood speaks (p. 176) of Jurassic shells as being "preserved in aragonite", and quotes Dr. Sorby as being of the same opinion. But is Mr. Horwood sure that his shells are still in the aragonite condition? Sorby,[2] when he writes of "aragonite shells", means as a rule shells that were formed of aragonite at the time of the death of the originating animal; but he describes how, in many of our fossiliferous rocks, such shells are represented either by hollow spaces or by pseudomorphs in granular calcite.[3] He points out that oolitic grains, originally consisting of aragonite, have similarly been changed into calcite, the more stable form of calcium carbonate.[4] Some oolitic grains, however, were thought by him to have consisted of calcite from the outset. Doelter,[5] after summing up Linck's researches on calcite and aragonite, states that calcareous oolites now consist of calcite; and we have no doubt that the "recrystallized aragonite concretions", quoted by Mr. Horwood from Sorby, were held by Sorby to be at the time of examination in the calcite state.

Sorby and other workers before 1901 have been compelled to rely upon the test of specific gravity and of relative hardness in distinguishing between calcite and aragonite in shells. A number of interesting observations were brought together in a classic paper by Gustav Rose,[6] who employed the microscope in determining the

[1] Geol. Mag., 1910, p. 173.

[2] Quart. Journ. Geol. Soc., vol. xxxv, Proceedings, pp. 65, 83, 93, etc., 1879.

[3] Ibid., p. 68.

[4] On the relative stability of calcite, see H. W. Foote, "Über die physikalisch-chemischen Beziehungen zwischen Aragonit und Calcit": Zeitschr. für physikalische Chemie, Bd. xxxiii, p. 753, 1900.

[5] *Petrogenesis*, p. 225.

[6] "Über die heteromorphen Zustände der kohlensauren Kalkerde": Abhandl. Akad. d. Wiss., Berlin, 1856, p. 1, and 1858, p. 63. Rose's first researches on the mineral forms of calcium carbonate were published in Poggendorff's *Annalen*, Bd. xlii, p. 353, 1837. A French translation, containing a correction of a slip on p. 361 of the German paper, appeared in the *Annales des Mines*, 1837, p. 611.

mineral nature of many shells. Haidinger[1] observed that aragonite, when heated, flew into fragments, which he believed to be calcite, and Rose showed that these really consisted of calcite, with a specific gravity of 2·709. Rose noticed how under certain conditions of precipitation rhombohedra of calcite were formed, while aragonite was deposited under others, its globular forms changing in time into calcite rhombohedra.[2] It is easy to precipitate aragonite from lime water with ammonium carbonate, and to note under the microscope, as Meigen has done,[3] the gradual assumption of the calcite condition, which involves, of course, a change of volume. The fact that the precipitate consists of aragonite may now be determined by a prompt use of Meigen's solution, to be referred to later. The precipitate must be freed from ammonium carbonate by thorough washing, since this salt gives in a solution of cobalt nitrate a fine violet deposit of cobalt carbonate.

The question with which the present paper is concerned is the rate at which the change from aragonite to calcite takes place in *fossil shells during geological time.* The shell is not free to destroy its intimate structure and to group its molecules in new arrangements unless it can break up entirely into a number of granules of calcite, or unless the excess of calcium carbonate, present in the aragonite state, but not required in the calcite state, can be accommodated somewhere, or removed in solution as the change goes on.

Aragonite with a specific gravity of 2·94 expands 8·088 per cent. in turning into calcite with a specific gravity of 2·72. Such an expansion is comparable in amount with that which accompanies the formation of ice from water; and it is quite possible that ordinary pressures in sedimentary rocks are sufficient to restrain it. In any case, where the change of mineral condition takes place in a fossil shell without alteration of its bulk and form, it seems likely that solution has been at work. It may be urged that the organic matter occupies considerable space in the living shell, and that the hollows left by its decay are sufficient to accommodate the molecules of calcium carbonate when re-arranged in the calcite state. But this would not apply to the numerous cases of the conversion of oolitic grains from aragonite to calcite, and here removal of material by solution seems the only explanation.

It should be remarked that Rose[4] found that microscopic crystals of aragonite, which he obtained by evaporation of a solution of calcium carbonate in water containing carbon dioxide, retained their form even after heating, although their specific gravity of 2·700 showed that they had passed into the calcite state. Rose described them as true pseudomorphs, in which an expansion and re-arrangement of the particles had taken place. But such an expansion of every oolitic grain and shell-fragment in an oolitic limestone seems improbable.

[1] "Ueber die Veränderungen, welche gewisse Mineralien, etc.": Poggendorff's *Annalen*, Bd. xi, p. 177, 1827; also Trans. Roy. Soc. Edin., 1827.

[2] Op. cit., 1856, p. 1.

[3] "Beiträge zur Kenntnis des kohlensauren Kalkes": Ber. naturforsch. Gesell. Freiburg i. Br., Bd. xv, p. 1, 1907.

[4] Poggendorff's *Annalen*, Bd. xlii, p. 363, 1837.

In determining the specific gravity of modern shells, the organic matter presents a difficulty, as was, of course, recognized by Sorby.[1] Sorby estimated the specific gravity of this matter as 1·5, and obtained its proportion by weight by carefully burning it off, and restoring, by treatment of the residue with a solution of ammonium carbonate, any carbon dioxide that might have been lost. The specific gravity of the shell in its original condition, the masses of its two constituents, and the density (1·5) of one of them are known; the density of the other, the calcium carbonate, can then be calculated.

Professor W. J. Sollas[2] shows that 12·5 per cent. of organic matter will reduce the specific gravity of a shell from 2·9 to 2·725, while 14·37 per cent. will bring it to 2·7, a value commonly afforded.

When Professor E. H. L. Schwarz[3] argued in 1894 that the shell of the modern *Nautilus* consisted of calcite, since its specific gravity was 2·68, he may have been misled by the presence of organic matter. As soon as his paper was published, one of us obtained a similar result for *Nautilus* (2·70), while the shell of *Spirula* was found to have a density lower than 2·60. The organic jelly obtained on dissolving the latter shell was, however, very conspicuous. It seems possible that the value obtainable may vary in modern shells according to the conditions to which they have been subjected, and that long exposure to sunlight and the attack of organisms on a tropical beach may reduce them to the state of fossil shells. It is clear, however, that organic matter may remain present for a long time, since bleached shells of *Mya* gathered from a raised beach in Green Bay, Spitsbergen, yield a considerable amount of jelly on solution.

Professor Schwarz proceeded to argue that the shells of ammonites, which are often missing, and which are commonly formed of calcite when preserved, originally consisted of calcite, like their aptychi. Sorby, however, had already stated the specific gravity of the shell of *Nautilus* as 2·95,[4] and had suggested the presence of a little calcium phosphate in addition to aragonite. The internal shell of *Sepia* yielded him 2·91. Hence the ammonites also have been generally held to have had shells of aragonite, which have passed gradually into calcite.

Using Sollas's diffusion column and methylene iodide, one of us made the following determinations on fossil shells in 1894, calcite and aragonite being the floating indices in the liquid :—

Nautilus, Gault, Folkestone. 2·73. Calcite.

Cœlonautilus carinatus, Carboniferous Limestone, County Limerick. 2·68. Calcite.

Cosmoceras Jason, Oxford Clay, Chippenham. 2·675. Calcite.

Harpoceras Brighti, Oxford Clay, Christian Malford. Would not sink until powdered, probably through air-cavities. The powder

[1] Quart. Journ. Geol. Soc., vol. xxxv, Proceedings, p. 59. See also Rose, *Abhandl. Akad. Wiss.*, Berlin, 1858, p. 68.

[2] "On the Physical Characters of Calcareous and Siliceous Sponge-spicules and other Structures": Sci. Proc. R. Dublin Soc., vol. iv, p. 390, 1885.

[3] "The Aptychus": Geol. Mag., 1894, p. 457.

[4] Op. cit., p. 60. Cf. Cornish & Kendall, "On the Mineralogical Constitution of Calcareous Organisms": Geol. Mag., 1888, p. 71.

mostly yielded 2·755, but ranged from 2·58 to 2·79. Possibly some aragonite or dolomite.

Hoplites lautus, Gault, Folkestone. Two separate specimens, 2·75 and 2·79. Probably some iron pyrites present.

Hamites intermedius, Gault, Folkestone. 2·71. Calcite.

Aptychus, Kimmeridge Clay, Ely. 2·688. Calcite.

Belemnites giganteus, guard, Lias. 2·677. Calcite.

Psiloceras planorbis, Lower Lias, Watchet. Six pieces from one specimen gave respectively 2·88, 2·88, 2·93, 2·94, 2·97, and 2·97. One of the pieces giving 2·88 was then powdered; the bulk of the powder floated at a level indicating 2·80. The powder ranged, however, from 2·65 to 2·98. Internal mineral differences here probably interfere with a true result, but the indication of aragonite is remarkable.

This last result gave cause for thought. Can aragonite be retained in the shells of ancient deposits, and under what conditions? Rose[1] has recorded aragonite crystals on the walls of the fibres of *Inoceramus Cuvieri* from the Plänermergel of Strehlen; but it does not appear that he traced shells consisting of aragonite into deposits of any antiquity. Tschermak[2] remarks that the proportion of aragonite decreases in older shells, although this mineral is found in fossil shells. No further observations, however, are recorded by him on this point. Messrs. Cornish & Kendall[3] deal mainly with the solution of aragonite shells, rather than with their replacement by calcite. It is not clear that Sorby[4] meant to assert that certain Gastropod shells in the Barton Clay remained in the aragonite state. He calls attention to the preservation of their structure, but is inclined to suggest partial silicification to account for it. As already stated, his use of the phrase "aragonite shells" seems by no means to imply shells *now* consisting of aragonite.

It seemed to us important, then, to see how far "aragonite shells" can remain as aragonite in geological time. We have always to remember in such an investigation that, when we meet with a fossil shell of high specific gravity, there is the possibility of partial phosphatization. This difficulty was indicated by Sorby, but has been removed in recent years by the ingenious test devised by Herr Meigen[5] to distinguish calcite from aragonite. Powdered aragonite, as is now well known, turns lilac after boiling in a solution of cobalt nitrate; while calcite, unless extremely finely powdered, gives no reaction.

The standard solution used in the following experiments was prepared by adding two volumes of water to one volume of a cold saturated aqueous solution of cobalt nitrate. The time of boiling in

[1] "Über die heteromorphen Zustände der kohlensauren Kalkerde": Abhandl. Akad. d. Wiss., Berlin, 1858, p. 80.

[2] *Mineralogie*, 1884, p. 418.

[3] "On the Dissolution of Aragonite Shells in the Coralline Crag," Geol. Mag., 1883, p. 497; and "On the Mineralogical Constitution of Calcareous Organisms", ibid., 1888, p. 68.

[4] Op. cit., p. 77.

[5] *Centralblatt für Min.*, etc., 1901, p. 577, and *Ber. naturforsch. Gesell. Freiburg i. Br.*, Bd. xv, p. 20, 1907.

each case was three minutes. The first materials tested, to establish a standard method, were powdered calcite and aragonite.

Chemically prepared tricalcic orthophosphate gives a fine violet reaction, and this has led one of us into the error of stating that apatite "gives a blue precipitate".[1] Several varieties of apatite and phosphatized fossils tested by us are, as a matter of fact, found to give no reaction, and this clears the way as regards the occurrence of calcium phosphate in shells the specific gravity of which resembles that of aragonite.

Since Meigen mentions only results with artificially prepared strontium and barium carbonates, it may be useful to state that we find that two specimens of strontianite, one from the Harz and one from Westphalia, give a *blue* reaction, while witherite turns violet like aragonite. Magnesites from Haute Vienne and Silesia and siderite from Cornwall give no reaction.

Seeing how colour-changes occur unexpectedly in certain reactions, we tested pyrite, marcasite, and a number of pyritized fossils, but without result. We may conclude, then, that the violet reaction on which we rely in our observations is a true indication of aragonite. The presence of witherite is too improbable to vitiate the argument.

Among Recent specimens we tested *Nautilus pompilius* and *Arca Noœ*; both show the aragonite reaction. *Tubipora* retains its red tint, but gives no indication of aragonite.

Pliocene. Professor Kendall[2] showed that aragonite shells may be removed altogether in solution from the permeable Coralline Crag. Those that remain are not likely to have been converted into calcite. The following were tested and consist of aragonite. Chillesford Beds: *Mya arenaria.* Red Crag: *Cardium Parkinsoni.*

Miocene. Burdigalian: Leognan, *Arca Girondica* and *Turritella terebralis* are both aragonite.

Oligocene. Aquitanian: Mérignac, *Arca cardiiformis*, aragonite.

Eocene. The "aragonite shells" sometimes show friability and indications of partial solution; but they seem able to hold their own in a remarkable degree against transformation into the calcite state. The following were tested, and all seem to be in their original mineral condition. The one calcite shell in the series is *Ostrea submissa*, from the Yprèsian of Cuise-la-Motte; but, as is well known, the oysters form their shells of calcite. All the following are aragonite. Bartonian: Haravilliers, France, *Arca biangula.* Lutetian: Chaumont-en-Vexin, *Eupsammia trochiformis*; Bracklesham, *Litharœa Websteri* and *Arca duplicata*; Chaumont-en-Vexin, *Cardium porulosum* and *Turritella carinifera.* London Clay: London, *Nautilus regalis.* Lower London Tertiaries (Thanetian): Chislehurst, *Cyrena cuneiformis.*

Cretaceous. Gustav Rose[3] found crystals of aragonite on the fibres of *Inoceramus Cuvieri* from the Plänermergel of Strehlen. Messrs. Cornish & Kendall[4] determined that *Parasmilia centralis* from the

[1] *Aids in Practical Geology*, 6th ed., p. 36.
[2] Geol. Mag., 1883, p. 497.
[3] *Abhandl. Akad. Wiss.*, Berlin, 1858, p. 80.
[4] Op. cit., Geol. Mag., 1888, p. 72.

Upper Chalk is calcite, with a specific gravity of 2·70. We have verified this with Meigen's solution, and regret that it is difficult to find other suitable fossils for comparison. *Spondylus*, for instance, possesses an outer calcite layer, while *Ostrea* and *Pecten*, both common in the Chalk, form calcite shells. The Cephalopods, other than *Belemnites*, from the Chalk are usually in the form of casts, and there is a general dearth of material that might have been aragonite at its time of deposition. From the Upper Greensand of Devizes, however, we have a specimen of *Arca carinata*, which has the decayed and crumbly look of an old aragonite shell; and this proves to be actually aragonite.

When we come to the Albian horizons, we possess numerous fossils from the Gault Clay which have remained in the aragonite condition. The following are all aragonite: Folkestone, *Cyclocyathus Fittoni*, *Alaria carinata*, *Hoplites tuberculatus*, *Hoplites splendens* (two specimens); Mid-Surrey, *Nucula pectinata* (showing a characteristic powdery appearance). On the other hand, the following from the Gault of Folkestone have passed into calcite: *Solarium ornatum*, *Nautilus*, *Hoplites lautus*, *Hamites elegans*. A *Solarium* again, from an unrecorded Gault locality, has remained as aragonite.

It is clear that local conditions have allowed a majority of Gault shells to remain unaltered, while others have undergone change in geological time. We may expect to find this change emphasized in Jurassic strata.

Jurassic. Coral Rag: West of England, *Thecosmilia annularis*, *Thamnastræa arachnoides*; both calcite. Kelloways Rock: Christian Malford, *Cosmoceras Elizabethæ*, calcite. Bath Oolite: Minchinhampton, *Arca hirsoniensis*, *Arca Prattii*, *Arca minuta*; all calcite. Inferior Oolite: *Parkinsonia Parkinsoni*, calcite. Middle Lias: Cheltenham, *Macrodon Buckmani*; Lyme Regis, *Ægoceras Henleyi*; both calcite. Mickleton, *Ægoceras capricornus*, aragonite. Lower Lias: Robin Hood's Bay, *Psiloceras planorbis*, calcite; Watchet, *Psiloceras planorbis*, aragonite.

The interest here is concentrated on two ammonites. The *Ægoceras* from Mickleton is very well preserved in a slightly argillaceous limestone, while the *Psiloceras* from Robin Hood's Bay is also in a clayey limestone. That from Watchet is in a shale; it was this specimen that raised the question of the retention of aragonite in ancient strata, when its specific gravity was found, in 1894, to be as high as 2·9. We have examined Jurassic *Arcas* specially as a type, and it is clear that there is a very general tendency for "aragonite shells" of this period, when they survive at all, to be preserved as calcite.

Trias. Red marine strata of Han Bulog, Bosnia, *Ptychites striatoplicatus*, calcite.

Carboniferous. Carboniferous Limestone, *Cœlonautilus carinatus*, calcite. Shale, Cuilcagh, *Orthoceras*, calcite.

Finally, we have verified Sorby's observations on Oolitic limestones, with the foreseen result that, while the oolitic grains from the modern Great Salt Lake of Utah consist of aragonite, those of Jurassic age from Portland, Leckhampton, and Dalberg in Hanover have passed into calcite.

It is obvious that a research of this nature may be indefinitely extended; but enough has been here set down to show that Mr. Horwood may be justified in expecting some retention of aragonite even in Jurassic strata. The change into calcite in stratified deposits is really very slow. Aragonite shells are often affected by solution in Cainozoic strata, but not ordinarily by conversion into calcite. A study of compact Eocene limestones may be expected to show calcite pseudomorphs, at any rate in some parts of the world; but European clays and sands alike seem to allow of the retention of the aragonite state, until we reach well back into the Cretaceous period.

In the Gault of Folkestone we have a tendency for the development of calcite. It would be interesting to know if this occurs in certain zones, where percolation of water happens to be more free. Certainly the evidence of Jurassic limestones is strongly in favour of the general change of aragonite into calcite in beds of this age, though aragonite may exceptionally be preserved in certain argillaceous strata. We can now hardly expect to find aragonite in shells older than the Jurassic period.

Sorby[1] held that aragonite shells often broke down into "fine-grained calcite mud", and were thus lost sight of in limestones. Rapid accumulation might, he thought, have saved them in some Jurassic limestones; but even then it is not clear that he regarded the shells and corals thus preserved as still consisting of aragonite. We ourselves find no evidence of the disappearance of aragonite shells by granulization. Unless actually dissolved, they may remain as aragonite, with their original forms and structures, though they have come down to us from the opening of Cainozoic times.

In view of the instability of aragonite as precipitated in certain chemical experiments, it is interesting to find that the same substance, when organically deposited, holds its own so well through a long series of geological periods.

II.—The 'Dragon-tree' of the Kentish Rag, with Remarks on the Treatment of Imperfectly Petrified Woods.

By M. C. Stopes, D.Sc., Ph.D., F.L.S., Lecturer in Fossil Botany, Manchester University.

In the early numbers of the Geological Magazine the 'Dragon-tree' received considerable attention. It was thought to be a Monocotyledon and described as a species of *Dracæna* by Mackie in 1862 (*Geologist*, p. 401, pl. xxii). The specimen appears to have attracted an unusual amount of interest prior to 1870, and it is referred to by Mantell and other contemporary writers. Carruthers placed it among the British fossil Pandanaceæ in 1868 (Geol. Mag., p. 154). Like other specimens from the sandstones of the Iguanodon Quarry (Lower Greensand of Maidstone), no internal structure appeared to be preserved, and the determination of its nature rested entirely on the external features.

[1] Quart. Journ. Geol. Soc., 1879, Proceedings, p. 83.

In his Wealden Catalogue Seward points out that there is nothing in this fossil to indicate that it had an Angiospermic affinity, and in 1896,[1] in a review of the supposed fossil Angiospermes, he amplifies this and gives the plant the non-committal name of *Benstedtia*. This genus he places among the Cycads, illustrating the likeness between the markings on the outside of the fossil and those on the living species of *Zamia Skinneri*. This superficial similarity is very close, and is well illustrated in his pl. xiv. The particular point on which stress is laid in the comparison is the presence of irregular transverse ridges and grooves, instead of the usual armour-plate of leaf-bases common in Cycads.

Since the Maidstone Benstedtias have been described a few specimens have been found elsewhere. Among the fossils of the Uitenhage Series of South Africa are some which are put by Professor Seward in the genus *Benstedtia*. In this paper[2] Professor Seward remarks that the casts called *Coniferocaulon colymbeæforme* by Fliche appear to be identical with *Benstedtia*. These casts, like our specimens, show no internal structure whatever.

As Professor Seward remarks (loc. cit., p. 217), since none of the wood structure is retained in the fossils conclusive evidence as to their nature is not to be looked for. He notices the wood-like appearance towards the middle of the largest of the specimens, but observes that it is of purely mineral nature.

One of the objects of the present paper is to record the fact that I have found true wood remains in these fossils. In the course of my work on Cretaceous plants I have had occasion to re-examine the figured specimens, and have one or two further observations to offer concerning their botanical affinities.

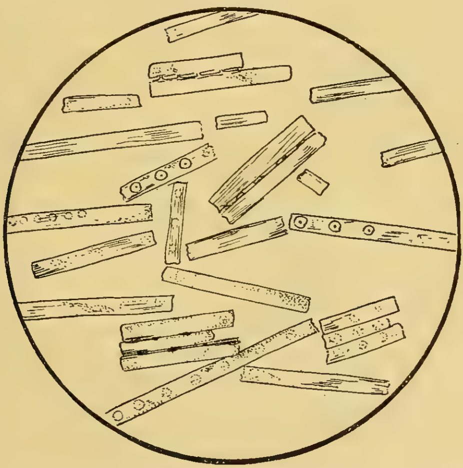
In the British Museum there are more specimens than have been mentioned by previous writers. One of these lends support to the doubt I feel that in the casts of *Benstedtia* described by Professor Seward and others we are really dealing with the external features of the plant. The likeness of the external appearance of these casts to those of the true exterior of *Zamia Skinneri* is without doubt; but if in the fossil we are not dealing with true external features the comparison ceases to be of any value. No. V. 9572 in the British Museum shows two layers of this supposed exterior superimposed for a short distance, and with nearly a centimetre of matrix between them. This evidence is, of course, not conclusive, but it suggests that the 'exterior' represents zones of cortex or bark at various levels in the decorticated stem.

Close examination of the largest specimen (No. 8357), to which all previous English writers have referred, revealed that there *is* a remnant of true wood in the axis of the cast. The crystalline matter simulating wood, mentioned by Professor Seward in his account of this specimen, is clearly to be recognized, and is distinct from the true remains of woody tissue.

[1] *Annals of Botany*, vol. x, pp. 216 et seq., 1896.

[2] "Fossil Floras of Cape Colony": Ann. S. African Mus., vol. iv, 1903, see pp. 34–6.

Previous work on extremely ill-preserved woods in greensand matrices had prepared me to deal with wood in the condition of a white, semi-silicified, fibrous mass, which crumbles to the touch. As such remains are the only form which vegetable fossils take in some deposits, it may be of value to note the simple point of technique which I have found useful. With such specimens collodium casts are not obtainable, as the collodium sinks into the fibrous surface and does not form a proper film. Ordinary sections are out of the question; examination with a hand lens gives one no clue to the nature of the wood, because it is generally so incompletely preserved as not to show even its annual rings. I have found, however, that if one selects a portion of the wood remains free from matrix, the point of a sharp pen-knife will free with the lightest touch some of the fibrous powder of the wood. If this powder is then mounted on an ordinary slide, soaked in water for a short time under a cover-glass, it will be found that it consists of short lengths of individual tracheids, generally separate from each other or lying in pairs.



Some of the powder from the pulverizing wood, as seen under the microscope, showing the separate lengths of the tracheids, some of which show bordered pits.

Many of these tracheids show no markings, but in most woods that I have examined, however poor they may be, at least a few of the tracheids show their characteristic pittings. In this way I have recognized in minute scraps of pulverizing wood true Abietineous pitting, with round bordered pits in single rows, and other woods with *Brachyphyllum*-like pits in irregular pairs. The sharpness of the border in these bordered pits (which show sometimes the small central opening also) is remarkable, considering the unpromising nature of the material. In a few cases short lengths of medullary rays accompany the tracheids, but in general one does not get more than the tracheal markings to work upon. These, however, are sufficient to determine the main group to which the plant belongs.

When, therefore, I found traces of pulverizing woody remains in *Benstedtia* I examined them critically, and by this simple method was able to determine that the wood of *Benstedtia* was gymnospermic, and that the tracheids had circular bordered pits, lying in a single row at some distance from each other. These are quite unlike the Cycads, which have several rows of closely adjacent pits. Although this does not make it possible to determine the exact genus to which *Benstedtia* must have belonged, it yet proves without doubt that the plant was one of the higher Coniferæ, probably of the Taxodineæ or Abietineæ: the Araucarineæ, Taxaceæ, and Cycads are eliminated from the plants available for comparison.

Fliche, Bull. Soc. Sci., Nancy, 1900, pp. 15 et seq. (I am indebted to Professor Seward for reminding me of this paper), compares casts of French specimens which have surface features like *Benstedtia* (with which, however, he does not compare them) with the living Araucarias, and in particular with the section Colymbea. In the absence of internal structure in his specimens this comparison may still hold good, for there is nothing to show that his plant was not an Araucarian type. As in the similar British specimens, however, the wood is that of the higher Coniferæ, it may probably appear later that the French specimens belong to this group also. This is further supported by one of our fossils, which practically proves that the transversely ridged 'exterior' is not necessarily the true outer surface of the plant as it was when alive. Fliche assumed that his transversely ridged stem was directly comparable to the Araucarinene he mentions.

It has not been easy to find among living Coniferæ a parallel development to the curious transverse ridging which is conspicuous in some of the specimens of the fossil, and which is so like the *Zamia* figured by Professor Seward. In most of the specimens available there seemed no possible stage of decortication that would give a parallel to the features in the fossil. In some of the very contorted and warped specimens of trunks which are common enough in plants grown under unfavourable circumstances, I found that the wood splits down so as to give a rippling, transversely ridged surface, very similar to the fossil. Also trunks with such warped and contorted woods simulate the apparently dichotomizing trunk figured by both Mackie and Seward.

The curious little rounded protuberances in these ridges in some specimens figured by previous observers and taken by Professor Seward to be a feature of the plant itself are not present in all the specimens, and appear to me to be possible of interpretation as the ends of teredo borings, left, not as true borings, but as impressions of borings in the cast of the ripple-surfaced wood. Such wood, splitting longitudinally so as to give a rippled surface, can be seen at Kew in the collection of conifer woods, and, as teredo borings of the diameter of the protuberances in the fossil are not at all uncommon for this geological horizon, this explanation of the whole structure, though dull and prosaic, has the merit of probability and simplicity. The hollow stem which some have attributed to the plant is without doubt due to decay preceding petrifaction.

Except for historical interest, and for the convenience of having a name by which to designate a special kind of cast of a genus known otherwise (compare the *Knorria*, etc., of *Lepidodendron*), there appears no reason now to give *Benstedtia* a generic name of its own. In describing the African plants Professor Seward retained the name *Benstedtia*, for, as he said (1903, p. 35), "without anatomical evidence . . . a non-committal term such as *Benstedtia* is preferable" to the specific name given to similar things by Fliche, which attributes to them distinct affinities. As, however, we have now direct evidence in the details of the wood tracheids that our British specimens belong to the Coniferæ, but are not Araucarian, it seems best to include them in the genus *Coniferocaulon* of Fliche and retain König's original specific name *Benstedii.* Fliche's specimens, although very probably really belonging to the same true species, may be left under Fliche's specific name till his view as to their nature is proved or disproved by evidence of internal structure. Our plant, then, the *Dracæna Benstedii* of König, the *Benstedtia* sp. of Seward, is best designated by the name *Coniferocaulon Benstedii*, and placed among the higher Coniferæ.

Though the 'Dragon-tree' was a much more romantic figure before its ordinary gymnospermic features were revealed, consolation for this loss may perhaps be afforded by the fact that it illustrates the use that even pulverizing fossil wood may be in determining affinities of doubtful plants, when handled with a method so technically simple as that described above.

III.—Fissureless Volcanoes.

By Dr. Hans Reck.

As I could not give in this paper anything like a full account of my observations and the results of my studies concerning this question made during an expedition through Iceland in the summer of 1908, I must refer the reader to my special papers on this subject.[1] Everyone will find there the reasons which have induced me first to suppose the independence of the so-called 'Schild' volcanoes in Iceland of pre-existing fissures. This idea is confirmed by collecting proof after proof on the subject in the field during my researches. Naturally I could not give all the details in a first short preliminary communication, a fact which, I am sorry to say, has caused Professor Schwarz to doubt the correctness of part of my observations and conclusions. I may therefore be allowed to discuss shortly the two main objections of Professor Schwarz to my theory.[2]

Briefly summarized, the facts are as follows: Out of the level highlands of Central Iceland a few block-like, square-formed, flat-topped

[1] Hans Reck, "Ein Beitrag zur Spaltenfrage der Vulkane": Centralbl. f. Min., Geol., u. Palaeont., 1910, No. 6, pp. 166–9, 1 fig. "Ueber Erhelbungskratere": A. d. Monatsberichten d. Deutschen Geol. Ges., Bd. lxii, No. 4, pp. 295–319, 9 figs., 1910. "Isländische Masseneruptionen": Kokens geol.-palaeontolog. Abhandlungen, Heft ii (Bd. ix der neuen Folge), pp. 80–186, 9 plates, 1910. "Das vulkanische Horstgebirge Dyngjufjöll mit den Einbruchskalderen der Askja und des Knebelsees sowie dem Rudloffkrater in Zentralisland": Abhandlungen der Königl. Preuss. Akademie der Wissenschaften vom Jahre 1910, pp. 1–100, 8 plates.

[2] See Geol. Mag., September, 1910, p. 392.

mountains rise abruptly from the plain at their feet to a height of 1,000 to 1,200 metres. Their summit plateau consists of lava gently rising from all sides to the crater. All the mountains in question show exactly the same lines and details of structure, so that it may be just as well here to confine myself to the description of Herdubreid only as a type for all the others. The summit plateau ends abruptly on all four sides with vertical walls which show a clear and fresh section of the mountain structure, as all the detritus is constantly being removed by the wind, and no vegetation hides even the finest details of the composing rocks. Only the lowest part of Herdubreid up to the height of a few hundred metres is hidden by huge accumulations of debris.

Beneath the lavas of the upper region follows the main bulk of the mountain, consisting of palagonite tuff. Here it is that one would expect to find a fissure if such existed. It must be stated that all the four mountain walls are practically vertical, uninterrupted, even, and stand at right angles to one another. Two of these lie in the general N.–S. line of all the tectonic and volcanic lines of fissure eruptions in the north of Iceland, but all these faults are of more recent date than the volcano, as parts of it are disturbed by their dislocations. Older faults are up to now not yet known in the surroundings of Herdubreid.

In the palagonite tuff of the north side of Herdubreid, where we ought first of all to expect to find a volcanic fissure, an horizontal line is to be seen separating a brighter- from a darker-coloured part of the tuff. The uninterrupted course of that line all along the wall absolutely proves that there is at least no line of *dislocation* on which the volcano could have appeared. Furthermore, the absolutely uniform structure of the tuff, not only here but on all sides, seemed to me proof enough that there was not only no dislocation but just as little a line of weakness or a fissure. A fissure open at the time of the first outbreak of the volcano and no longer open to-day must have been closed since, either by filling up with lava from below or with detritus from above, or, as Professor Schwarz seems to believe, by tectonic movements which, without dislocations, would have pressed together the edges of the fissure.

The first objection of Professor Schwarz is, that a fissure might exist in the palagonite, but be healed and thus made invisible to the eye. For this he adduces a most instructive example from the Berg River, Hoek, near Paal, in Cape Colony. He has stated that there a great fracture was healed, and the rock brecciated and hardened to a distance of 3 to 4 yards on both sides. Supposing now such a fracture with brecciated and hardened sides would run through the even, vertical, fresh wall of Herdubreid. In the quick process of decomposition of the soft palagonite tuff such a hardened zone of brecciated material would necessarily manifest its character by standing out from the wall as a dyke. On the other hand, it would naturally have to appear as a ravine if the rock along the fault was only brecciated and thus loosened in its structure but not hardened afterwards. But neither the least signs of brecciation nor of unevenness in the perpendicular mountain side could be observed.

Similarly a fissure filled from below with lava or from above with debris would always be distinguishable by the necessarily different structure of the in-filling material compared with the uniform composition of its surroundings, so that after all I can only repeat my first statement: It is therefore here for the first time proved from observation that in this case at least a fissure does not exist under the base of a volcano for a depth of from 300 to 400 metres.

Professor Schwarz's second theoretical objection is, that, granted there were no line of weakness in the palagonite itself, one might better regard the volcano as the offshoot of a deeper-lying volcanic fissure than to admit it having been formed by piercing its own way up through the earth's crust even from the magma basin whence it derived its lavas.

There are several reasons which, unfortunately, do not allow me to agree with Professor Schwarz's ideas. First of all I must repeat that there is no fault known in the whole volcanic surroundings of Herdubreid that is proved or even likely *to be older* than the volcanic activity of the mountain which began after the ice of the last glaciation had long been melted away.[1] At any rate the fractures and dislocations by which the surroundings of Herdubreid sank down for at least 600–700 metres, and left it as a huge mountain block in its old position, are younger than the volcano, for they have dislocated even the youngest outpours from its crater.

The reason that allowed Herdubreid to keep its old position can only be found in its being a 'Schild', or massive lava volcano, with an axis of solid lava under its central parts, which served as a strong support against the sinking movements of the surrounding crust.

The volcanic axis piercing the base of the volcano in no place touches the vertical walls of the volcanic 'Horst', so that from this fact it is only probable that the chimney would go down rather perpendicularly, which is also theoretically necessary to assume from reasons which I have given in the above-mentioned papers, and which are based on the symmetry of the shape of the volcano. So that, even if we were inclined to assume an old fissure under the lava-covered surface of the surrounding level plain, the offshoot of the volcano would necessarily have taken place very deep below the surface.

But why at such a depth should the rising magma suddenly have left the line of weakness which would have led its lavas in the easiest and shortest way up to eruption? I think it will be rather difficult to find sufficient reasons for even a theoretical explanation of this, but there is one more point which seems strongly to negative the assumption of an underground fracture as the conduit for the magma.

Professor Schwarz assumes Herdubreid to be an offshoot of a volcanic fissure, and adduces as example for the possibility of his opinion Daubrée's well-known experiments on the exploding of dynamite in steel shells. He also gives a very interesting example of a "fossil earthquake", as he has termed it, which in its course showed characters of a similar kind. In his latter example single blocks,

[1] Compare also Helgi Pjeturss, *Zeitschrift der Gesellschaft f. Erdkunde*, 1908, pp. 451 ff.

torn off from below, have drilled cylindrical holes into the overlying Karroo shales.

Now one cannot possibly imagine Herdubreid with a circumference of, let me say, about 14 km., measured along the vertical walls, to be a block torn off and shot up from the underlying ground. Not even a slow upward movement can explain all the facts to be observed, as I have shown in a previous paper. The great bulk of the mountain in a similar way makes it very difficult for me to imagine it as something like a parasitic cone in comparison with a great volcano. For where is the great volcano or the grand volcanic fissure of which Herdubreid should be a parasite? Neither of them is at present known in Iceland.

If we compare Professor Schwarz's hypothesis of Herdubreid as an offshoot of some unknown volcanic fissure, and Daubrée's experiments, with the facts observed in nature, we are confronted at once with the question: Do all the leading features really coincide in nature and in the experiment? In Professor Schwarz's theory as well as in Daubrée's experiments gases are the moving factor of the eruption, and their prevailing action is the necessary proposition to the experiment, as it depends mainly on their explosive force. Do we find anything like that in the case of Herdubreid? Observation gives not the least support to the assumption of any explosions worth mentioning, neither in the beginning of the first eruption nor during the course of later ones.

By climbing up the steep cliffs of palagonite and lava in ascending the top of Herdubreid for the first time I actually passed over the entire section across the mountain, and had to climb from sheet to sheet of the basaltic lava-flows of the upper region. But neither at the base of the lowest one nor as accumulations between later outflows could I find loose volcanic material such as ashes, lapilli, bombs, pumice, or broken pieces of the ground, which are the most evident companions of all volcanic explosions. On the contrary, the want or but feeble display of explosions is one of the most characteristic peculiarities of the 'Masseneruptionen', of fissure eruptions as well as of the eruptions from central craters in the case of lava volcanoes. No 'Schild' volcano is known in Iceland to have erupted in historic times, but all the characteristics of the crater and its surroundings point to a mechanism of eruption just as we can observe it in the huge lava volcanoes of Hawaii, Kilauea, and Mauna-Loa, where in historic times all the eruptions but one have taken place without the development of any remarkable explosions. From none of the many 'Schild' volcanoes of Iceland is explosive material known, and Herdubreid is no exception to the rule. Therefore I must conclude that not the gases but the magma itself has been the main force which led it to eruption. In the course of long-repeated gentle outflows it piled up the Herdubreid mass. But as no indication of a surplus of gases is recognizable in the erupted materials I think it most improbable that explosions, which would have drilled a cylindrical pipe through the ground—either on a fissure or beside it—took place during the origin of Herdubreid.

Thus the gradual ascent of lava with but little gas in a pipe must have caused the first outbreak of Herdubreid, not the offshoot of an exploding mass of gases accompanied only by lavas. In this fact lies the great difference between Daubrée's experiment and the physics of eruption in the case of Herdubreid. With Herdubreid the cylindrical form of the pipe must therefore be due to other reasons than the ones adduced in the case of explosions.

Different reasons are possible. The most probable seems to me in accordance with Suess's and Branca's opinions, that the rising column of lava has forced its own way through the superincumbent crust until it reached the surface. But this or other explanations which see the moving force in the rising magma itself seem to me to negative the possibility of a fissure as a line of weakness being the outlet of an upward pressing magma, which would not in doing so assume the shape of a dyke, but would wear out a perfectly cylindrical canal along the fissure on its way upwards.

There are many more reasons to prove the fissureless nature of the Schild volcanoes in Iceland, but it is not the object of this paper to give them. The reader will find them published in the above-mentioned papers. Here I only wanted to show that I was well aware that this probably unique example in the world of a volcano being exposed on all sides a few hundred metres below its base, would be a serious objection to the theory which sees a fracture in the earth's crust as the necessary primary origin of all volcanoes. I therefore was especially careful in examining all the eventualities which could possibly have concealed a fissure below the volcano, but all observations as well as theoretical conclusions do not leave the least doubt that in this case volcanic force found its way to the surface without the help of a surface fissure. Furthermore, theoretical conclusions and comparisons of the products and the outer appearance of these lava volcanoes with the mechanics of eruption make it most probable to me that not even in the deeper parts of the crust a fracture has served them as a line of weakness; but that, probably by melting its way through the crust, the lava forced its own way from the magma basin below up to the eruptive point at the surface.

IV.—Preliminary Note on the Geology of South-Eastern Kincardineshire.

By Robert Campbell, M.A., B.Sc., Geological Department, University of Edinburgh.

The district under consideration embraces that part of the county of Kincardine which lies south of the Highland fault. Excellent maps on the 1 inch and $\frac{1}{4}$ inch scale have been issued by H.M. Geological Survey, but no detailed description of the geology of the area has yet been published. Most of my vacations during the past three years have been spent in studying the geology of this interesting region, and although the work, which has included detailed mapping of the whole area on the 6 inch scale, is not yet complete, several points have been made out, the importance of which has led to the publication of this preliminary note.

Upper Cambrian (?).

Between Craigeven Bay and Garron Point occurs a series of crushed green igneous rocks with thin intercalated black shales, jaspers, and cherts, which are shown on the Geological Survey Maps as of Arenig (?) age. In August, 1909, on the occasion of a visit to Craigeven Bay in company with Dr. B. N. Peach and Mr. W. T. Gordon, we spent some time in searching for fossils in the above-mentioned sediments, and in the black shales we succeeded in finding organic remains, including a linguloid shell and a bivalve phyllocarid crustacean. The assistance of Mr. D. Tait, of H.M. Geological Survey, was obtained in making a detailed search in the fossiliferous beds. He collected a remarkable suite of fossils which have thrown important light on the age of these rocks. Dr. Peach, in whose hands the fossils were placed for determination, has very kindly supplied the following note:—

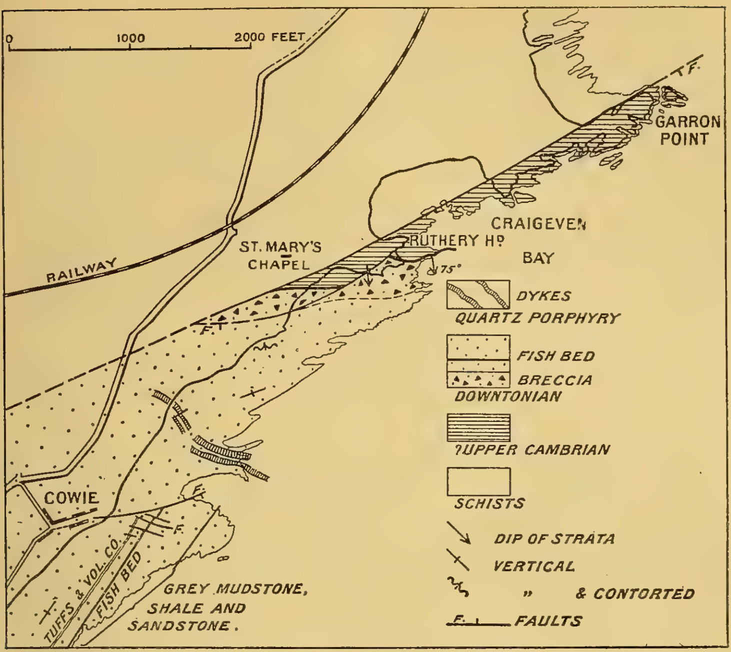
"The collection includes several specimens of hingeless brachiopods belonging to the genera *Lingulella*, *Obolella*, *Acrotreta*, *Linnarssonia*, and *Siphonotreta*; a few specimens of a bivalve phyllocarid allied to *Caryocaris* and *Lingulocaris*; cases of a tubicolar worm, the structure of the tubes being like that of the modern *Ditrupa*.

"Without further study it may be premature to express a definite opinion about the horizon of these fossils. The genera represented are most commonly found in the lowest division of the Lower Silurian (Ordovician) system and the Upper Cambrian. The absence of graptolites, however, suggests that they may belong to the latter rather than to the Lower Silurian."

These rocks extend as a narrow belt from St. Mary's Chapel to Garron Point (see Sketch-map). Whatever may be the ultimate decision as to their stratigraphical horizon, it will readily be admitted that the fossils must determine also the age of the similar groups of green crushed igneous rocks and associated sediments which occur at intervals along the Highland border.

The Highland Fault.

The Highland fault has hitherto been represented as a normal fault forming the boundary between the Old Red Sandstone formation and the older rocks to the north-west. A visit to the coast section at Craigeven Bay, in company with Dr. B. N. Peach, showed us that, along the south shore of the bay, what has hitherto been regarded as the Lower Old Red Sandstone formation rests unconformably on Upper Cambrian (?) strata. This boundary-line has always been looked upon as marking the line of the Highland fault, and, indeed, masked as the unconformity is by minor faulting and by the red staining of the underlying rocks, it is not perhaps surprising that the basement breccia has been mistaken for a fault breccia. The northern boundary of the Cambrian (?) is an overthrust fault, and this line of faulting is probably the continuation of the great Highland fault, which elsewhere in this district forms the northern limit of the Old Red Sandstone. In the only inland section in Kincardineshire in which the actual line of fault was seen—in a small stream near Elfhill, about 6 miles west of Stonehaven—the fault is undoubtedly an overthrust.



Sketch-map of Geology of the Coast of Kincardineshire from Cowie to Garron Point.

Upper Silurian (Downtonian).

Owing to the discovery of fossils in beds overlying the basement breccia, a considerable thickness of what has been regarded as Lower Old Red Sandstone must be considered as of Downtonian age. The succession of these rocks as shown in the coast section from Craigeven Bay to Stonehaven Harbour is as follows (in descending order):—

	Feet.
9. Tuffs and volcanic conglomerate	300
8. Brown micaceous sandstone	800
7. Tuffs and tufaceous sandstone	800
6. Grey sandstone and fossiliferous sandy shales and mudstones (with fish-band)	600
5. Red sandstone	60
4. Volcanic conglomerate and tuffs	40
3. Grey and brown sandstones with thin red mudstones . .	1000
2. Purple sandstone	60
1. Basement breccia	200

The basement beds consist of breccias with intercalated thin red sandstones and sandy mudstones. The breccias are made up almost entirely of angular fragments of the igneous rocks and jaspers of the underlying Cambrian (?) strata, but they contain also occasional subangular and rounded pebbles of granite and schists. The unconformity which marks the base of the series may be traced along the northern face of the headland at Ruthery Head, and thence in an easterly direction along the foreshore to low-water mark. Although the unconformable character of the junction is obscured to some extent, as noted above, still the marked difference in direction of the main structural lines in the two series of rocks is quite sufficient to allow of the unconformity being traced with absolute certainty. The planes of bedding in the Downtonian strata dip at a high angle to the south-south-east; the main structural planes in the Cambrian (?), both cleavages and bedding, in igneous and sedimentary rocks alike, dip towards the north-west. An overthrust fault which crosses Ruthery Head in a north-easterly direction shifts the outcrop of the lowest breccia 160 yards to the south-west. From this fault the unconformity can be traced for a considerable distance along the foreshore in a westerly direction (see Sketch-map).

While a detailed description of the whole succession cannot be attempted in a short preliminary paper, two further points will be dealt with.

1. The series of grey sandstones and sandy shales and green and grey mudstones (No. 6 in above table), alike in lithological character and in fossil contents, show quite clearly the Silurian rather than Old Red affinity of this succession. About 20 yards east of Cowie Harbour is a thick belt of grey and greenish mudstones and shale which yield *Dictyocaris* in great abundance. On visiting this section in August, 1909, in company with Dr. Peach and Mr. W. T. Gordon, we found not only *Dictyocaris* but also *Eurypterus* sp. and fragmentary plant-remains, and Mr. Gordon discovered in a thin bed of reddish sandy mudstone several fish-plates. Some of the fish-fragments were suggestive of *Birkenia*. Mr. Gordon and Dr. Peach joined me again during the past summer in order that we might try to get material sufficient to establish the horizon of this fish fauna. Considerable additions were made to the finds of the previous summer. The fishes were submitted to Dr. R. H. Traquair, who has been good enough to send me the following preliminary note:—

"The fish-remains from Cowie, Stonehaven, consist of—

"First: Small scutes which are about three times as long as they are broad, slightly convex on one side and correspondingly concave on the other, and apparently pointed at both ends. They seem to me to be referable to the category of Cephalaspidian scutes, only the external ornament, where visible, consists of longitudinal and slightly wavy striæ in place of tubercles. That the species to which they belong is as yet unnamed and undescribed is pretty certain, but the advent of additional material is desirable before proceeding further in that direction.

"Second: Several fragments of thin, minutely tuberculated plates which may also be Cephalaspidian, though their nature is indeed problematical.

"Third: Two median plates of a beautiful new *Cyathaspis*.

"The specimens from the grey sandstones overlying the fish-band consist of irregular blackish and reddish blotch-like films, which, on examination with a lens, show in many cases a honeycomb-like marking, consisting of minute polygonal areæ, whose margins are on one side of the stone raised, on the counterpart incised. These markings are at once suggestive of the middle layer of the Pteraspidian shield, but in none of the specimens is any trace found of the inner layer or of the outer layer with its markings. More likely does it seem that these films are of the same nature as the problematic *Dictyocaris* of Salter from the Upper Silurian of the Pentland Hills, which occurs in similar blotch-like masses and shows very similar polygonal markings.

"As to whether the Cowie fish-remains indicate a Lower Devonian or an Upper Silurian (Downtonian) horizon, they in themselves afford no certain answer to the question, beyond this, that *Cyathaspis*, although it occurs in Lower Devonian rocks, seems, according to number of species, to be more characteristically a Silurian genus. If, therefore, the associated invertebrate remains favour the reference of these beds to the Downtonian horizon, that idea would be corroborated rather than the reverse by the relics of fishes noted above."

Apart from plant-fragments, worm-tracks, and *Dictyocaris* the remaining fossils belong to the Arthropoda. They include *Ceratiocaris* sp. (carapace, rostrum, and cercopod); *Archidesmus* sp. and a new genus of Myriopod; (?) larval form of insect; *Eurypterus*, sp. nov.; fragments of scorpion. These Arthropoda will be described by Dr. Peach, to whom I am indebted for the above provisional determination.

Although the typical Downtonian fishes of the south of Scotland have not so far been met with in Kincardineshire, yet the occurrence of *Ceratiocaris* and *Dictyocaris*, neither of which has hitherto been found in rocks younger than Upper Silurian, would appear to indicate that these Cowie beds are of Downtonian age. This view, as pointed out by Dr. Traquair, is apparently corroborated by the association of these fossils with *Cyathaspis*.

Since I returned to Edinburgh I have learned from Dr. Horne that in 1881 Mr. MacConnochie, of H.M. Geological Survey, collected from the 'Stonehaven Beds' on the shore near Cowie, and from the prolongation of the same beds exposed in the Carron Water, west of Tewel, specimens of *Dictyocaris*, together with fragments of *Pterygotus*, *Eurypterus*, and (?) *Kampecaris*. From the abundance of the remains of *Dictyocaris* Dr. Peach at that time suggested that the beds containing these fossils might be of Upper Silurian age.

2. In the excellent account of the volcanoes of Lake Caledonia in his *Ancient Volcanoes of Great Britain*, Sir Archibald Geikie[1] has correlated the initial outbreak of volcanic activity with the coming on of the conditions which gave rise to the massive quartzite conglomerate south of Stonehaven Harbour. That volcanoes were active in this area at a much earlier period is seen from the great development of tuffs and volcanic conglomerates in the Downtonian sequence. The lowest volcanic conglomerate is about 2,500 feet below the above-mentioned quartzite conglomerate. It can be traced inland until it is lost against the Highland fault, and everywhere the

[1] *Ancient Volcanoes of Great Britain*, vol. i, p. 303.

predominating constituents in the conglomerates and tuffs are rhyolites and hornblende-biotite andesites. It seems clear, then, that early in Downtonian times (or perhaps in pre-Downtonian) rhyolites and acid andesites flowed out in abundance over the schist and granite country to the north of the Highland fault. Further evidence of the existence of this series of volcanics is obtained from the character of the sediments of the Lower Old Red Sandstone formation.

The highest beds in the above table pass conformably up into the massive quartzite conglomerate of Downie Point, which may be considered as the base of the Lower Old Red Sandstone.

Lower Old Red Sandstone.

While the palæontological evidence here is so meagre that it affords little assistance, lithological evidence, on the other hand, obtained from conglomerates, lavas, and tuffs, has aided materially in elucidating the structure of the area occupied by the Lower Old Red Sandstone.

The conglomerates fall into two well-marked classes: (1) those in which quartzites or other 'Highland' rocks predominate; (2) those which are made up almost entirely of volcanic rocks—volcanic conglomerates. Detailed examination of the character and distribution of these conglomerates is being carried out. Meanwhile mention may be made of some points which are of especial interest.

In the 'Highland' conglomerates at different horizons occur numerous pebbles of greywacké, including many of the 'Haggis Rock' type, showing just as little evidence of schistosity as the greywackés of the southern uplands. The boulders of 'Haggis Rock' consist chiefly of angular and subangular fragments of jasper, chert, and 'green rocks' (probably spilitic lavas), the rock types which predominate in the Cambrian (?) Series at Craigeven Bay. In all probability these boulders have been derived from the Margie Series described by Mr. Barrow.[1] All the 'Highland' conglomerates contain boulders of the jasper-green rock series. In many of the conglomerates low down in the succession these rocks are almost the only types represented; it is only in the highest conglomerates that they begin to play an insignificant part. The evidence given by these conglomerates seems to point conclusively to a former wide extension of Cambrian (?) and Margie rocks over the country now occupied by the granites and Dalradian schists.

Thick volcanic conglomerates, the pebbles of which are chiefly acid andesites and rhyolites, occur at three different horizons, and, in one case at least, the conglomerate has its maximum development at the Highland fault. Further, the sandstones at every horizon contain invariably a considerable amount of the debris of rhyolites and acid andesites. Here again, as in the Downtonian succession, there is evidence of long-continued denudation of a series of acid lavas, which must have extended far to the north of the Highland fault.

Only one limestone has been noted in the Lower Old Red Sandstone succession. It occurs at several localities in the Howe of the Mearns,

[1] Q.J.G.S., vol. lvii, p. 331, 1901.

and probably occupies the same horizon as a limestone which has been mapped by H.M. Geological Survey for several miles in the Plain of Strathmore.

Fossils have been collected from four horizons. The above-mentioned limestone has yielded plant fragments, while in the associated red flagstones worm-tracks have been observed. In a series of grey and greenish sandstones and mudstones in Den of Morphie, *Parka decipiens* occurs in great abundance, along with *Kampecaris forfarensis* and fragments of *Pterygotus anglicus*. The sandstones at Three Wells Quarry, near Bervie, separated from the above fossiliferous beds by a thick series of hypersthene and augite andesites, have yielded specimens of *Cephalaspis Lyelli*. From the grey sandstones in Strathlethan Bay, which immediately overlie the lowest quartzite conglomerate, specimens of *Parka* sp. have been obtained.

Evidence of prolonged volcanic activity is found in the great development of lavas, tuffs and agglomerates, and hypabyssal intrusions. The lavas include one flow of rhyolite and at least two of hornblende-biotite andesite. The predominating types, however, are basic, and consist of hypersthene andesites, augite andesites, and basalts. The tuffs are all acid in character. The hypabyssal intrusions of presumably Lower Old Red Sandstone age include quartz porphyries, porphyrites, lamprophyres, and dolerites.

The main structural feature is a continuation of the well-known synclinal fold of Strathmore. In the area to the west of Elfhill, however, there is a tendency to set up a steep-limbed anticline pitching out to the south-west against the Highland fault. The southern limb of the syncline is traversed by numerous powerful dip faults.

Upper Old Red Sandstone.

In the neighbourhood of St. Cyrus on the Kincardineshire coast there is an outlier belonging to the Upper Old Red Sandstone Series. Although no fossils so far have been recorded, the type of sedimentation leaves no doubt as to the age of these rocks. Their junction with the Lower Old Red Sandstone Series is shown on the Survey maps as a natural boundary. In his description of the coast section Mr. George Hickling [1] has pointed out that the southern boundary is a fault, and he suggests that the northern boundary either is a fault or the Upper Series is banked up against an old cliff of the Lower. It has been found that the former supposition is the correct one.

Dykes later than Old Red Sandstone.

A number of quartz dolerite dykes have been mapped which have a general east-north-east and west-south-west trend. They are of the same type as the widely distributed east and west dykes of the central valley of Scotland.

[1] Geol. Mag., Dec. V, Vol. V, p. 405, 1908.

V.—On the Teeth and Buccal Structures in the genus *Conulus*, Leske.

By Herbert L. Hawkins, B.Sc., F.G.S.

(PLATE III.)

THE question as to the existence and characters of the jaws in *Conulus albogalerus*, Leske, has long been a subject of controversy. On prima facie evidence it seemed probable, so long as the genus was retained among the Holectypoida (the Galeritidæ of older authors), that jaws existed. *Conulus* appears as a successor to *Discoidea* among the Cretaceous Echinoids, and, with a few exceptions, all echinologists admitted that the latter genus was armed with a lantern and teeth. The truth of this assumption was proved by Lovén (Lovén, 1892, p. 53), and the details of the jaw structure were elaborated recently by myself in this Magazine (pp. 148–52, Pl. VI, 1909). That *Conulus* should be classed among the Holectypoida seems to be an established proposition, and it appeared in the early part of the Cretaceous period, together with *Pyrina*, probably as an offshoot from the *Holectypus* line of descent.

The history of the search for jaw-structures in *Conulus* shows some of the most remarkable contradictory results that are to be met with in the whole range of the study of fossil Echinoids. In 1829 Charles Stokes, in a letter published (in extract) in the Geological Society's Transactions (Stokes, 1829), announced the discovery, in '*Galerites*' (*Conulus*) *albogalerus*, of structures which he called 'plates of the mouth'. His figure is quite clear, and these structures (now known as 'buccal plates') have been found in many specimens since that time. Des Moulins, in the first of his memoirs on Echinoids (Des Moulins, 1835, pp. 191 and 324), referred to Stokes' account, and was undecided as to whether the structures were teeth or jaws. Grateloup (1836, p. 159) classes *Galerites albogalerus* among those species which have the 'bouche armée'. Desor expressed the opinion that the structures were the extremities of jaws (Desor, 1842, p. 13), and copied the figure.

The first definite statement on the subject was made in 1850 by Edward Forbes, who described and figured (Forbes, 1850, p. 3) the jaws and teeth. Desor (1857, p. 181) seems to have accepted the validity of this observation. The figures of the teeth are not very convincing, but they were copied by d'Orbigny in the *Paléontologie française* (d'Orbigny, 1859, pl. 996, figs. 9–10), and by Wright (1874, pl. 1, figs. 5–6). Wright held that the buccal plates were vestiges of a true 'lantern'. Lovén, in his *Études sur les Échinoidées* (Lovén, 1874), placed the 'Echinoconidæ' among the 'Échinoidées à dents'.

The first denial of the presence of jaws came in 1884, when Duncan, in a somewhat dogmatic paper, attacked the foundation of the figures and descriptions given by Forbes and Wright, and denied the possibility of the existence of dentigerous jaws in *Galerites* (*Conulus*) *albogalerus* (Duncan, 1884, p. 11). He established the fact of the presence of tubercles on the outer surface of the buccal plates (which seemed to preclude their derivation from any part of the lantern), and, basing his observations on some specimens in the British Museum, maintained that the teeth described by Forbes were imaginary, or founded merely on grooves caused by a tool in the soft chalk within the peristome. As a result of his conclusions he placed '*Galerites*' among the Echinonidæ.

Following on so uncompromising a denial, almost all subsequent writers have regarded *Conulus* as a toothless form. In 1900 Gregory took this view (Gregory, 1900, p. 316), although retaining the family Galeritidæ among the Holectypoida, while in the same year Sladen placed the genus among the Echinonidæ (Sladen, 1900).

With the exception of the last two references, which are of a general character, all the discussion was concerned with *Conulus albogalerus*, one of the latest members of the genus, and certainly the most readily obtained and studied in this country. A small, tumid form of this species is very abundant in the uppermost layers of the zone of *Micraster coranguinum* in the South of England. I recently collected more than fifty specimens from this '*Conulus* band' in a chalk-pit near Kingsclere, and neither in the interior of the specimens nor in the matrix in which they were so thickly scattered could I detect the smallest trace of any structures comparable with normal Echinoid jaws. In the case of one specimen, in which the buccal plates were in situ, and by their presence narrowed the mouth opening to a very small circle, there was no macroscopic fossil inside the test excepting two stray buccal plates which must have drifted in with the infilling chalk.

I made this search as a result of the discovery by the late A. Agassiz of teeth and a lantern in a young specimen of *Echinoneüs* (Agassiz, 1909). After having destroyed fifty specimens and rubbed down (with a brush) a very considerable quantity of their matrix with no result, I came to the conclusion that Duncan was justified in his scepticism. It was therefore with great surprise that, on examining a series of *Conulus subrotundus*, Mantell, in the British Museum, I found a specimen[1] with the peristome enlarged by cutting and four glistening, enamel-like teeth projecting towards the aperture. Whether this specimen is the one on which Forbes based his account of teeth in the newer species, or not, is a question which seems unanswerable. There is no information as to the locality from which the specimen was collected, nor as to whose hand cleared out the peristome. (The only information with the specimen was 'Upper Chalk', which is almost certainly inaccurate.) If, however, this should be the example referred to, the figures given in the Decade (pl. viii, fig. 10), and subsequently copied by d'Orbigny and Wright, owe a great deal to the imagination of the artist.

The specimen is of the form of *C. subrotundus*, found most frequently in the zone of *Terebratulina*, being tall, inflated at the sides, and rounded at the margin of the adoral surface. Judging from the intense hardness of the chalk within the test, it would seem to belong rather to the zone of *Rhynchonella Cuvieri*. It is, at least, safe to ascribe it to the Middle Chalk. It seems to be fully adult. For

[1] The specimen has been registered E. 10743.

some little distance within the peristome the chalk filling is soft and crumbling, but otherwise it is very hard.

After slicing off one side of the specimen I was able to develop the peristomial region in such a way that it could be viewed from the side. The appearance of the teeth after this operation is shown in Pl. III, Fig. 1. I subsequently extracted two of the teeth for detailed examination, and the following description is founded on these two examples only. The others seem identical in character.

The teeth are composed of extremely hard calcite with a porcellanous lustre. The more complete of the two specimens (Pl. III, Figs. 2–5) measures 6·7 mm. from the (accidentally) blunted tip to the inward end of the internal carina. The other is 7·0 mm. long, and has the point intact, but the rest of the tooth is not very well preserved. Except towards the tip, where for a distance of 1 mm. they taper to a point, both teeth have a uniform width of 1·4 mm.

The curvature of the whole tooth is very slight, as shown in Fig. 2. The convex surface is marked by a fairly prominent ridge (with angular margins) down the middle line, and two less conspicuous ridges down the edges. On the concave surface, which is slightly hollowed, there is an extremely prominent carina, which rises abruptly at a distance of 1 mm. from the point of the tooth, and in both specimens persists upwards beyond the blade.

It will be noticed that the above description agrees fairly closely with that given by Forbes in 1850. The teeth are strikingly similar to those of *Discoidea cylindrica* which I described a short time ago (Geol. Mag., 1909, p. 149, Pl. VI, Fig. 4). The length of these new specimens is greater than that in the case of *Discoidea*, but owing to the fact that all are broken, this is a point of no importance. The width of the *Discoidea* tooth is only ·9 mm., as against the 1·4 mm. in the *Conulus* examples. The extreme sharpness of one of the *Conulus* teeth shows a contrast to that of *Discoidea*, but the bluntness in the latter case (certainly not due to fracture) may have been the result of wear. The most important difference between the two genera, in the matter of their teeth, is the almost straight shape of the tooth in *Conulus*. I have copied the figure of the side view of the *Discoidea* tooth (reduced to the same scale as the others) to render this contrast more obvious. See Pl. III, Fig. 6.

In spite of the most careful search and very gradual development of the specimen, I found no trace whatever of jaws or any other structures beside the teeth. Although it seems impossible that teeth of such dimensions could exist, and especially be functional, in the absence of jaws for their support, yet it is almost less conceivable that they could have remained within the test while the jaws slipped through the peristome after the animal's death. An explanation of this apparent anomaly might perhaps be found in a suggestion that the jaws had advanced so far in degeneration that they were no longer calcareous, but I know of nothing in recorded jaw-structures that would support such a view.

The presence of teeth in *Conulus subrotundus* is established beyond doubt by the discovery of this specimen, but the question still remains as to whether similar structures existed in *C. albogalerus*. I have indicated above the strong negative evidence afforded by their absence in fifty specimens, in one of which the buccal plates remained intact. But such evidence is, of course, unsatisfactory. I can find no record of buccal plates having been detected in *C. subrotundus*, nor have I found traces of them among several hundred specimens, many very perfectly preserved, that I have examined. The perignathic girdle in this species is similar to that in *C. albogalerus*, but I have not found the small adradial process of the latter represented in the specimens dissected.

Duncan based part of his argument against the existence of jaws and teeth in *C. albogalerus* on the assumption that the buccal plates narrowed the mouth aperture to such an extent that there was no room for jaws to exercise their functions. The preparation of the peristome in the specimen above referred to, from the upper part of the zone of *M. coranguinum* (Pl. III, Fig. 7), shows the buccal plates from within, a view which, I believe, has not hitherto been described. Each plate has a deep pit in a groove towards the ambulacral margin. (Externally there are two tubercles in sunken areolæ, like those of the test.) The plates are roughly triangular, and each pair is in contact along almost the whole interradial margin. The position of the plates with regard to the grooves in the perignathic girdle suggests that they could slide up these, and so enlarge the diameter of the mouth opening. If this were the case, then perhaps a muscle was attached in the pit on the plate, and passed to the small adradial process of the girdle. Such an arrangement might conceivably be a modification from the characters and muscle attachments of the pyramids of a lantern, and then each buccal plate would be a degenerate demi-pyramid. The presence of tubercles on the outer surface is the only feature seriously antagonistic to this view. As buccal plates of this kind are not known in any other genus or species, living or extinct, it seems probable that the development of these tubercles is secondary, consequent on the external position of the plates, and that the buccal plates really are curiously modified remains of the jaws. If this were to be demonstrated by future discoveries, it would be difficult to understand how teeth could find their place in such pyramids, although the retractability of the plates would remove the difficulty of the small size of the oral aperture.

If buccal plates were to be found in *C. subrotundus*, there would be no reason why teeth should not occur in *C. albogalerus*, but in the absence of these structures in the earlier species, the following summary of the suggestions made here may show some approximation to the actual conditions.

Summary. *Conulus subrotundus* had teeth, of a type differing but little from those of *Discoidea cylindrica*, but the remaining parts of the jaw apparatus were either uncalcified or too delicate for preservation. *Conulus albogalerus*, developing along a somewhat different line, lost its teeth, but retained the pyramids of the jaws, modified to form buccal plates.

In conclusion, I wish to express my thanks to Dr. F. A. Bather, F.R.S., for his help and advice, and to Mr. T. H. Withers for the gift of several

specimens collected by himself which have been used to confirm my observations.

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EXPLANATION OF PLATE.

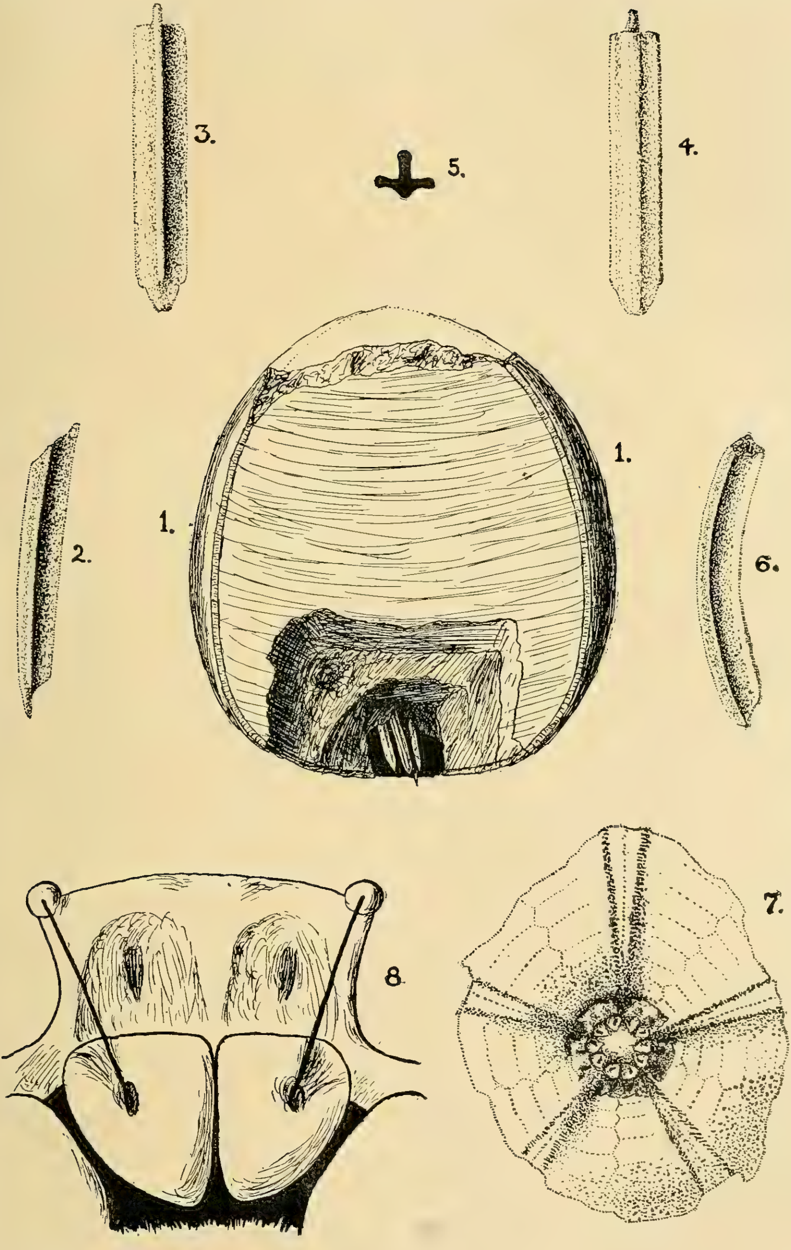
FIG. 1. Sketch of the specimen of *Conulus subrotundus* (in British Museum), showing the teeth in situ. × $1\frac{1}{2}$.
,, 2. Side view of tooth of same. × 6.
,, 3. Inner (concave) view of tooth. × 6.
,, 4. Outer (convex) view of tooth. × 6.
,, 5. Section of tooth. × 6.
,, 6. Side view of tooth of *Discoidea cylindrica*, for comparison with Fig. 2. × 6.
,, 7. Inner view of perignathic girdle and buccal plates of *Conulus albogalerus*. × 2.
,, 8. Diagrammatic sketch of the suggested method of movement of the buccal plates. The dark lines represent the positions of the retractor muscles.

VI.—FOSSIL MYRIOPODS FROM THE MIDDLE COAL-MEASURES OF SPARTH BOTTOMS, ROCHDALE, LANCASHIRE.

By WALTER BALDWIN, F.G.S., M.Inst.M.E., Government Geologist, Gold Coast, West Africa.

(PLATES IV AND V.)

IN the GEOLOGICAL MAGAZINE for December, 1907, a brief account was given by Dr. Henry Woodward, F.R.S., of the work of a small committee of Littleborough and Rochdale geologists, who have for several years been engaged in an examination of the Arthropod Beds at Sparth Bottoms, Rochdale. At Sparth Bottoms several beds



H. L. Hawkins del.

Jaw-structures in *Conulus*.

of greyish-blue shale, containing clay-ironstone nodules, crop out; the nodules have yielded to the hammer a surprisingly large number of new forms of Arthropoda, some of which have already been figured and described, and others still require further investigation. The beds exposed in the quarry are estimated by the author as 135 to 180 feet above the Royley Mine Coal Seam.

The following is a list of the Arthropoda which have been obtained from these beds:—

	Individuals.
CRUSTACEA.	
Belinurus lunatus, Martin, olim *B. bellulus*, König	250
B. Königianus, H. Woodw.	20
B. Baldwini, H. Woodw.	3
B. longicaudatus, H. Woodw.	2
B. testudineus, H. Woodw.	2
Prestwichia Birtwelli, H. Woodw.	36
P. (Euproöps) Danæ, Meek & Worthen	2
P. rotundata, var. *major*, H. Woodw.	} 25
P. rotundata, Prestwich, sp.	
P. anthrax, Prestwich, sp.	10
Pygocephalus Cooperi, Huxley	2
P. (Anthrapalæmon) Parkeri, H. Woodw.	1
Anthrapalæmon (?) sp.	2
Dithyrocaris sp., Scouler	4
Eurypterus sp.	fragments.
ARACHNIDA.	
Eoscorpius Sparthensis, Baldwin & Sutcliffe	1
E. (Mazonia) Wardingleyi, H. Woodw.	1
Eobuthus (?) rakovnicensis, Fritsch	1
Geralinura Sutcliffei, H. Woodw.	1
Anthracomartus trilobitus, Scudder	5
A. sp.	2
Anthracosiro Woodwardi, Pocock	1
Architarbus subovalis, H. Woodw.	1
Cyclus Johnsoni, H. Woodw.	81
MYRIOPODA.	
Xylobius Platti, Woodw.	1
Archiulus sp.	1
Euphoberia ferox, Salter, sp.	1
E. armigera, Meek & Worthen	1
E. robusta, Baldwin, sp. nov.	1
E. Woodwardi, Baldwin, sp. nov.	1
Acantherpestes major, Meek & Worthen	1
A. giganteus, Baldwin, sp. nov.	1
INSECTA.	
Stenodictya lobata, Brongniart	1

By the courtesy of my friend Mr. W. A. Parker, F.G.S., of Rochdale, several specimens of Myriopods have been placed in my hands for examination. They were all obtained from the beds at Sparth Bottoms, and the gentlemen who discovered them have kindly permitted me to figure and describe them. The specimens were all enclosed in clay-ironstone nodules, and were exposed by splitting the concretions open along their periphery.

TRACHEATA (Air-breathers of the Coal Period).

ARCHIPOLYPODA, Scudder.

Fam. 2. *Euphoberidæ*, Scudder.

Genus *Acantherpestes*, Meek & Worthen, Geol. Surv. Illinois, vol. iii (Palæontology), 1868, p. 556.

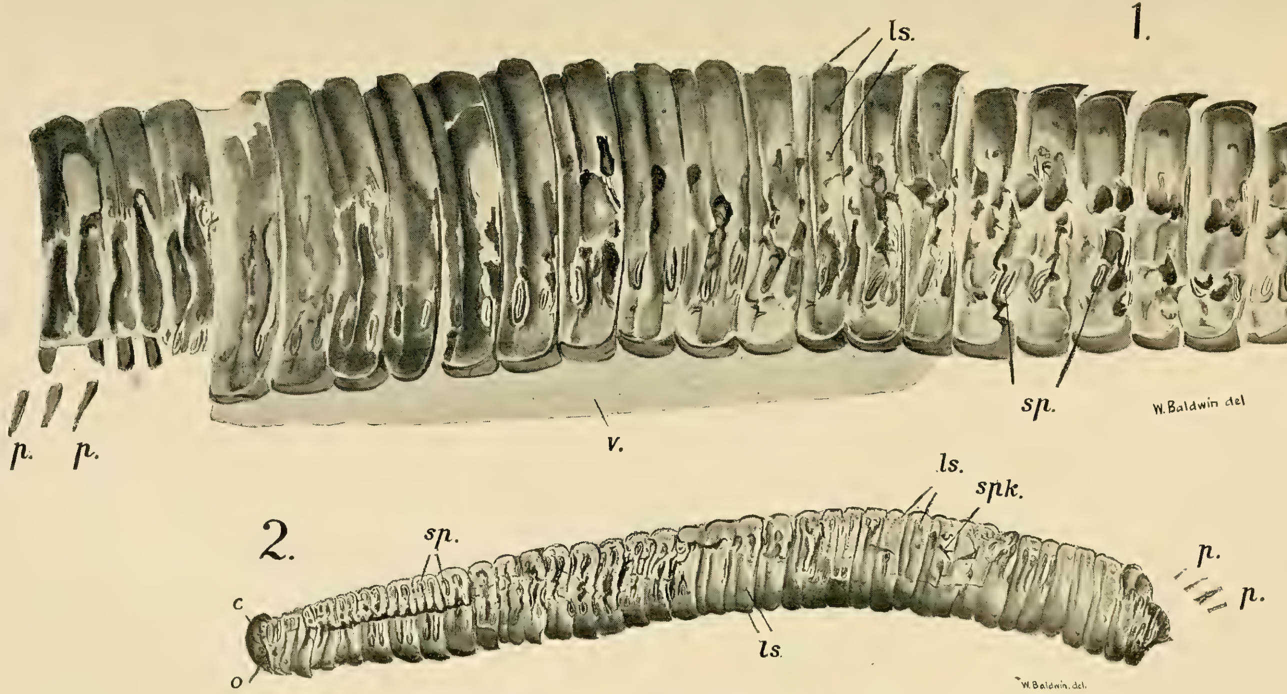
1. Acantherpestes giganteus, Baldwin, sp. nov. (Pl. IV, Fig. 1.)

This enormous specimen, which is to be presented to the Manchester Museum, and of which a figure is given here (Pl. IV, Fig. 1), was discovered by the author at Sparth Bottoms last June, and is contained in a large nodule weighing about 9 lb. 3 oz. Both sides of the nodule are preserved, and expose the dorsal view of a Myriopod, having indications of the tail and about twenty-five segments, measuring a total length of 195 mm. The telson (?) appears to possess a broad saddle which terminates in the middle in a three-cornered area that is very suggestive of *Acantherpestes gigas* (Fritsch).

Each dorsal segment is divided transversely into two parts by a furrow which extends to within a short distance of the lateral margin, dividing the segment into two portions in the proportion of 2 to 5. The anterior position is arched, whilst the posterior portion is curved to a height of 1·5 mm. The lateral borders of each segment are occupied by a broad depressed margin prolonged backwards into a triangular area very reminiscent of *Arthropleura*. The posterior portion of each segment bears bosses and scars, representing three rows of spines on each side of the body. The segments are all nearly of equal length, averaging 7·5 mm., their breadth varies from 18 to 44 mm., but the latter measurement should actually be considerably modified on account of the crushed state of the specimen. The change in breadth of the body is very marked, and occurs in the last four or five segments (this is probably caused by the loss of a part of the margin of these last segments, and by their slight dislocation).

The surface is apparently smooth, but when viewed with a strong lens under a favourable light is found to be minutely granular. In many places the surface integument has disappeared, revealing portions of the interior faces of the ventral plates, thereby exposing large ovate oblong spiracles that run transversely through the body, containing a deep groove with a thin laminate ridge along the middle; they are 2·75 mm. long and 0·75 mm. broad. On either side of the medio-ventral line of the body, and almost attingent at their slightly swollen bases, are the branchial cups, which appear as sunken pits, triangular in form. A few pairs of ambulatory appendages can be made out, two pairs being attached to each segment; they are stout, 2 mm. broad, and probably attained 21 to 22 mm. in length. One side of the specimen is very much flattened, and for about a length of thirteen segments a dark stain is observed next to the lateral border, and probably represents the soft portions of the animal which have been squeezed out by pressure.

This species differs from *A. major* in the shape of the segments, and is easily recognized on account of its enormous size, hence the trivial name.



W. Baldwin del.

Fossil Myriopods from the Middle Coal-measures, Sparth, near Rochdale. Nat. size.

Genus *Euphoberia*, Meek & Worthen.

2. Euphoberia armigera, M. & W. (Pl. V, Fig. 4.)

The specimen (discovered by Mr. Parker) of which a figure is given here (Pl. V, Fig. 4) appears to be identical with *Euphoberia armigera* of Meek & Worthen, and will be shortly presented to the Manchester Museum. Both sides of the nodule are preserved and reveal a lateral view of the Myriopod.

The intaglio exposes a clearer view of the creature and has been figured accordingly; there are indications of thirteen or fourteen dorsal segments, together with about nineteen ventral segments. The thirteen dorsal segments measure 39·5 mm., and taper uniformly towards the anterior end; they are equal in length (3 mm. each) and vary in breadth from 4 to 7·5 mm., being divided by a transverse depression in the proportion of 2 to 1, the broader or anterior portion showing indication of being spiniferous. The ventral plates, two to each dorsal segment, are somewhat blurred, average 1·5 mm. in length, and are about four times as broad as long. Fragments of about twenty-one legs are indifferently preserved. The body surface is smooth to the naked eye, but under a strong lens appears slightly granular.

The creature is attached to a portion of a stem of *Cordaites*, the whole being contained in a clay-ironstone nodule subovoid in shape, 70 mm. long by 60 mm. broad and 35 mm. thick.

3. Euphoberia robusta, Baldwin, sp. nov. (Pl. V, Figs. 3*a*, *b*.)

This large Myriopod (Figs. 3*a*, *b*) is contained on the relief half of a clay-ironstone nodule weighing about 1 lb. 10 oz. The creature is seen to be coiled dorsally, and measures 59·5 mm. in length as it lies on the stone, but would measure 68 mm. if extended. About seventeen segments are seen in front of the tail (?), but all somewhat flattened. At the broadest portion the segments are 18 mm. wide and at the narrowest 9 mm., whilst in length the segments vary from 3·6 to 2 mm.

The first eight segments preserved (except the first, which is broken) are of nearly uniform width, being 18 to 16 mm., with an average length of 3·6 mm.; after the eighth segment the Myriopod gradually tapers, presenting a very fusiform appearance, the dimensions being as below:—

	Width.	Length.
	mm.	mm.
Ninth segment . . .	15·5	3·60
Tenth segment . . .	15	3·50
Eleventh segment . .	14	3·25
Twelfth segment . .	13	3·00
Thirteenth segment . .	12	2·75
Fourteenth segment . .	11	2·50
Fifteenth segment . .	10	2·25
Sixteenth segment . .	9	2·00
Seventeenth segment . .	?	?

The segments are divided into two parts, the anterior two-thirds being slightly arched and spiniferous, whilst the posterior third is strongly arched and rises to an equal elevation with the former; the dividing furrow is deep. The surface is smooth, but presents minute pittings. The position of the lateral spines is indicated by small tubercles 0·5 mm. diameter, situated at about 2·75 mm. from the edges of the segments. The sub-dorsal rows are only indicated by a few pits, and appear at about 5 mm. distant from the lateral rows. The telson (?) is very badly preserved, but appears to be rounded.

On some of the segments the outer covering has decayed in such a manner as to expose portions of the interior of the ventral plates, revealing large oblong ovate spiracles that run transversely to the body and show as a deep groove with a thin laminate ridge along the middle; they are 1·5 mm. long and 0·4 mm. broad.

This species for size somewhat resembles *E. hystricosa* (Scudder), but is at once distinguishable by the shape of the dorsal segments. The stout and massive appearance has suggested to me the trivial name. This fossil was also discovered by Mr. Parker, who is presenting it to the Manchester Museum.

4. Euphoberia Woodwardi, Baldwin, sp. nov. (Pl. IV, Fig. 2.)

For the fourth example (Pl. IV, Fig. 2), which was found in the same measures, I am indebted to Mr. F. Howard, of Rochdale, who has very kindly placed the specimen from his collection at my disposal for purposes of examination and description. The Myriopod is exposed dorsally and measures about 12·4 cm. as it lies in the stone, and is represented by a head and thirty-eight segments measuring 7·5 mm. just behind the head.

The head, which is bent under, is broad, quadrate, with large oblique, many-celled eyes. The eye forms an oval boss 3 mm. long and 1·75 mm. broad, situated towards the anterior portion of the head, its longer axis vertical; it is covered with nearly hemispherical, circular cells, 0·5 mm. in diameter, crowded closely together, but not attingent, showing a slight indication of serial arrangement. Lying between the eyes is a well-marked circular depression 1·5 mm. in diameter, surrounded by an arched furrow that extends diagonally towards the anterior of the head, forming a four-sided plate that is very suggestive of Fritsch's *Acantherpestes gigas*. No antennæ are visible.

The seven segments succeeding the head gradually increase in breadth from 9 to 12·5 mm. and are of equal length (3·5 mm.). The remaining segments have a uniform breadth of 13 mm. and each measures 3·5 mm. long. Each segment is divided by means of a transverse furrow into two portions, a shorter anterior which is arched and a longer posterior which is flat, in the proportion of about 1 : 2. The posterior portion is spiniferous, the spines being indicated by blunt tubercles, forming two rows along each side of the body about 3 mm. apart. The spines appear (I have only been able to trace one and a few fragments detached) to be about 3 mm. long, consisting of a main stem that bifurcates at about two-thirds from the base, throwing off a branch about 1 mm. long at an obtuse angle. Both the main branch and the stem are slender.

The surface appears smooth, but in one or two places a delicate granulation may be seen, and a few segments exhibit a feeble wrinkling or faint corrugation of the surface.

Where the surface has been worn away hollow coxal cavities are exposed, and outside these are the large oblong ovate spiracles running transversely to the body, with a thin laminate ridge along the middle of each; they are about 1 mm. long and 0·5 mm. broad. The posterior end of the fragment exhibits portions of legs that indicate they are slender as compared with the bulk of the creature.

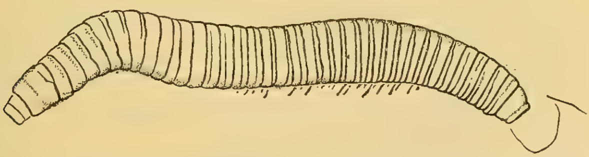
I have named this very interesting Myriopod after Dr. Henry Woodward, to whom students of fossil Arthropoda are so much indebted.

Fam. 3. *Archiulidæ*, Scudder.

Genus *Xylobius* (Dawson).

Xylobius Platti (H. Woodward).

A fifth and very perfect Myriopod (see Text-figure) discovered by Messrs. Sutcliffe & Parker and recorded by Dr. Henry Woodward at the British Association meeting, York, 1906, was named *Xylobius Platti* by Woodward in honour of the local work done by Mr. S. S. Platt, F.G.S., of Rochdale. It has been presented to the British Museum (Natural History), where it is registered [I. 13738]. I now append a figure and a short description of this interesting gally-worm. Length 50 mm. as it lies on the stone, or 54 mm. if extended, semicircular form, body cylindrical, of nearly uniform



Xylobius Platti, H. Woodw. MS. [Brit. Mus. I. 13738.] Middle Coal-measures: Sparth, near Rochdale. × ½ nat. size. Drawn by Miss G. M. Woodward.

width throughout the principal part, but slightly tapering towards either end. Consists of about forty-two segments. Breadth of body 3·50–6·5 mm. The head and two posterior segments measure 2·4 mm. The segments are a little convex, averaging 1·5 mm. in length per segment, their length to breadth as 1 : 4. Surface nearly smooth, frustra only slightly preserved. Both anterior and posterior borders slightly incrassated. Two pairs of legs to each segment, but not well preserved.

This species is nearly related to *Xylobius mazonus* of Scudder, from the Coal-measures of Mazon Creek, Illinois,[1] but in the American specimen the segments are more numerous, numbering as many as fifty; they are more parallel-sided, and their ornamentation of fine

[1] See S. H. Scudder, Mem. Boston Soc. Nat. Hist., vol. iv, No. 9, pp. 439–40, pl. xxxvii, figs. 7–11; and K. Zittel, *Handb. d. Palaeont.*, I, ii, p. 730, fig. 902, 1885.

transverse parallel lines is not so conspicuous as in Scudder's specimen. The head in the Sparth example is also smaller.

In conclusion, I beg to thank Dr. Henry Woodward for his kind assistance whilst preparing this paper, and those gentlemen who have so obligingly placed the material for description at my disposal.

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EXPLANATION OF PLATES IV AND V.

Plate IV.

FIG. 1. *Acantherpestes giganteus*, W. Baldwin, sp. nov. Nat. size. Middle Coal-measures: Sparth, near Rochdale. *l.s.* bases of spines; *p.p.* walking-feet; *sp.* spiracles; *t.* telson; *v.* stained surface probably due to extrusion of viscera.

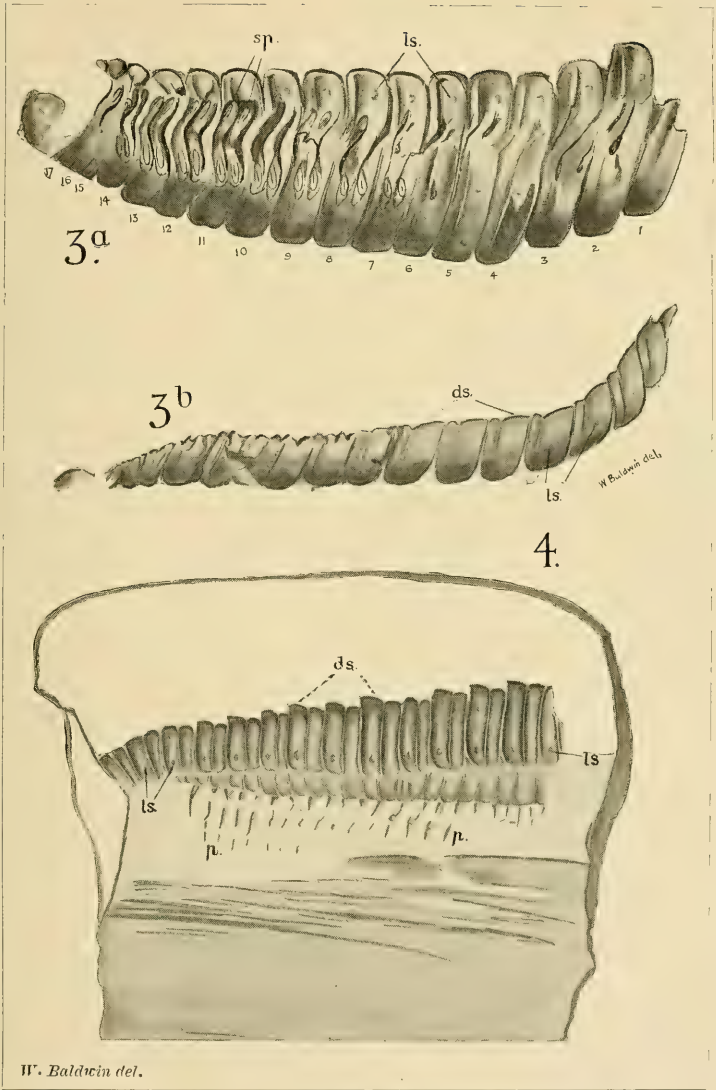
,, 2. *Euphoberia Woodwardi*, Baldwin, sp. nov. Nat. size. Middle Coal-measures: Sparth, near Rochdale. *l.s.* bases of spines; *p.p.* walking-legs; *spk.* spine (?); *c.* head; *o.* ocelli; *sp.* spiracles.

Plate V.

,, 3*a*. *E. robusta*, W. Baldwin, sp. nov. Dorsal surface. Enlarged 1½ nat. size. Middle Coal-measures: Sparth Bottoms, near Rochdale. *sp.* spiracles; *l.s.* bases of spines.

,, 3*b*. *E. robusta*, showing lateral view. Enlarged 1½ nat. size. *d.s.* dorsal surface; *l.s.* bases of spines.

,, 4. *E. armigera*, Meek & Worthen. Enlarged 1½ nat. size. Middle Coal-measures: Sparth, near Rochdale. *d.s.* dorsal surface; *l.s.* bases of spines; *p.p.* walking-legs.



Fossil Myriopods, Middle Coal-measures, Sparth, near Rochdale.
$1\frac{1}{2}$ nat. size.

VII.—Glaciers of the Yakutat[1] Bay Region, Alaska.

By R. M. Deeley, Memb. Inst. C.E., F.G.S.

THE United States Geological Survey has issued a paper, by Professor R. S. Tarr, of Cornell University, on the Physiography and Glacial Geology of the Yakutat Bay Region of Alaska. Here we have high coastal ranges, culminating in Mounts Cock and Seattle, from which descend great glaciers to the sea, and also other glaciers which come down to the waters of Russell Fiord. The whole region shows signs of intense glaciation during quite recent times, and on this account is an admirable area for the study of glaciers and their work.

That geology is still a living science is proved by the fact that we are not yet quite agreed upon many important points. That glacial geology is one of those matters about which there is at present a great deal of difference of opinion will be seen by anyone reading the Rev. Professor Bonney's Address to the British Association at Sheffield last year. Of late years in this country many geologists have been inclined to attribute very little erosive power to glaciers. A few, on the other hand, are of opinion that glaciers are quite powerful eroding agents, and consider that they have deepened valleys, excavated many lake-basins, and produced physical features which the ordinary atmospheric influences are now rapidly modifying. Under these circumstances the views formed by Professor Tarr, after a thorough study of a most instructive region, should be of considerable importance.

Although Russell considered that glaciers took immediate possession of the Yakutat region as it rose from the sea, Tarr, after a more thorough survey, considers "that there was profound denudation before the glaciers took possession of the region is indicated by the truncated folds and by the valley system in the peninsula, which is distinctly a system of mountain drainage lines, later occupied and profoundly deepened and broadened by ice".

Professor Tarr, after dealing in detail with all the main valleys, their glaciers, and the variable nature of their advances and retreats, as evidenced by the observations of previous explorers and the deposits they have left behind them, comes to the following conclusions:—

"Of all the hypotheses proposed, glacial erosion alone appears capable of explaining all the facts. It accounts for the broadened and greatly overdeepened main valleys, with truncated spurs, spurless walls, steepened slopes, and immature drainage lines; the U shape of the hanging tributary valleys; the non-progressive, irregular discordance in the hanging level of these; the difference in erosion from place to place; the irregularities of the valley bottoms and the through valleys—a combination of features which has never been described, except from a region which has been, or still is, occupied by glaciers.

"Against glacial erosion little has been urged further than the

[1] "The Yakutat Bay Region, Alaska: Physiography and Glacial Geology," by Ralph S. Tarr: United States Geological Survey, Professional Paper 64. 4to; pp. 184, 37 plates, 10 maps, and section. Washington, 1909.

argument that ice is not a powerful agent of erosion, and that it acts to protect rather than erode. This conclusion has been based largely on observations along the margins of weak dwindling valley glaciers.

"In the face of such evidence that ice *has* eroded, it is hardly demanded that one shall show that it really can erode. Nevertheless it may not be amiss to point out several facts bearing directly on the question. In the first place there was an enormous thickness of ice, supplied from many tributaries and without doubt flowing with comparative rapidity through the valleys. Second there is the direct evidence that ice was actually eroding. The *roche moutonnée* surfaces, the evidence of plucking, the polished, scratched, grooved, and fluted rock exposures in all parts of the inlet, and the extensive moraine deposits, all testify to the fact of erosion by the glaciers, and the existing glaciers add another evidence, namely, that of rock flour issuing from the ice fronts in the glacial streams.

"Whether one assumes that this erosion amounts to an inch in a year or an inch in a score of years, the fact of ice erosion must be accepted. One might see a small stream of clear water at the bottom of a deep gorge and say, correctly, that such a stream can not have formed so profound a gorge . . . But the flood stream, like the ice flood, is a different agent in degree."

It must be always remembered that all glaciated surfaces were last sculptured by the thin end of the retreating glacier which finished by polishing only. A finished statue frequently shows no signs of the rough work done by the chisel to commence with.

Between Russell Fiord and the Alsek River to the east the mountains rise to a height of four or five thousand feet. "The mountain slopes, where not too steep, are snow-covered, and all the valleys are deeply filled with streams of ice." "Such a condition of ice flood, drowning the valleys and rising high on the slopes of the mountains, which project as nunataks above the glaciers, is so different from that of the normal valley glacier that it seems to demand a special name; it is therefore proposed to apply to it the name 'through glacier'." In such a region the ice-flow will not always be from the divide. It will sometimes flow over a divide and cut a through valley like Russell Fiord itself.

Professor Tarr mentions an interesting case, which he saw, of a hanging valley glacier, more than a mile in length, slide bodily out of its valley; for this reason the valley was named Fallen Glacier Gulch.

It appears that the glaciers which enter the Russell Fiord are melted most rapidly at the surface of the sea. Below the water a snout of ice projects. Masses of this break off and rise to the surface. "Bergs immediately in front of the glacier are prevailingly either white, blue, or black in colour. The white bergs are derived from the ice walls above the sea; the blue ones, which are often a beautiful Antwerp blue, rise from below the water; the purely black icebergs, which are by no means uncommon, rise mainly from the base of the glacier, though a few fall from the debris-covered portions of the ice front." "In the warm summer air the blue icebergs quickly whiten." The sun breaks up the ice into its constituent granules, and the surface whitens owing to refraction and reflection from the granules.

Professor Tarr has made a most interesting contribution to glacial science. Only a few of the matters dealt with have been referred to, but the whole paper deserves careful perusal.

NOTICES OF MEMOIRS.

Relationship of Niagara River to the Glacial Period. Bulletin Geol. Soc. America, August 10, 1910, pp. 433–48.

In this paper Dr. J. W. Spencer records further observations made by him on the Whirlpool – St. David's Valley, Gorge and Canyon. The buried canyon occurs at the south end of the Whirlpool, some 3 miles from the escarpment. Above this is a shallower and smaller channel 2 miles further south. Beyond the ridge is another ancient valley trending to the south, and deepening to 66 feet in 1½ miles at the site of the falls themselves. In this distance the valley broadens from less than one quarter to over a mile, descending gradually a more gentle gradient throughout a longer course than that of the Whirlpool–St. David's Gorge. The buried gorge leading from the Whirlpool is bounded by compact limestones with steep faces, except where rounded and glaciated with striations along the direction of its course. This ancient and now buried gorge increases from 1,400 feet at the Whirlpool to 1,800 feet in a distance of 2½ miles. Professor Spencer discovered in this gorge, at a depth of 186 feet, the remains of a buried interglacial forest. Interglacial beds were first recorded in Canada by Mr. D. F. H. Wilkins, at Port Rowan on Lake Erie, in 1878. A little later, at Scarbo' Heights, east of Toronto, they were recorded by Dr. George Jennings Hinde, F.R.S. (*Canadian Journal*, Toronto, vol. xv, p. 388, 1878). This was the foundation of interglacial geology in the Ontario basin.

In the neighbourhood of the Whirlpool Gorge the surface of the Niagara limestone floor has been planed off, polished, and grooved, the strongest striations being to south 60° west and weaker ones south 60° east; best seen at the quarry on the mountain-top east of St. David's, where the drift is reduced in places to only 4 feet. Several well-sections are described, one of which passed through 293 feet in depth of glacial and other detrital deposits. Everywhere beneath the neighbouring drift-deposits lie buried channels, and high above the Whirlpool Channel is an esker-like ridge of sand and gravel rising at one point to 442 feet above the lake.

In the borings in Whirlpool Channel have been discovered remains of a cool climate forest and soil, at a depth of 186 feet below the surface, with proof of three or four glacial formations since that time, like the Pleistocene Series at Toronto.

Before the forest bed, at least two glacial formations had been left in the buried channel, below which lie some 100 to 200 feet of still older glacial deposits. This lowest drift lies in a rock-bordered valley which had undergone a far greater amount of erosion than that during or since the Glacial period. From all the evidence Professor Spencer concludes therefore that this now filled trough is of pre-glacial origin. The age of the modern Niagara River is also found to be younger than the glacial deposits about the western end of Lake Ontario, though not so recent as the later Wisconsin accumulations in other localities.

Before the birth of the falls the ice-sheet had receded beyond the greatest of all the moraines of Ontario, which lie between Lake Ontario and Lake Simcoe and between this lake and Georgian Bay, a distance of more than 120 miles north of Niagara Falls, so that the drainage of Lake Huron then passed down the Trent Valley. From the terrace north of Lake Nipissing the ice-sheet had receded 230 miles or more to the north of Niagara before the birth of the falls. But the Ottawa Valley farther down was still blocked. The Ontario Valley was open to at least near the eastern end of the lake, so that it permitted the flow from Algonquin Lake down the Trent Valley, although the ice was not removed from the St. Lawrence till some time after the birth of the falls. This was the last ice-sheet, and we only know that it disappeared so long ago that there was time for the excavation of the inner gorge of Niagara River, extending from Lake Ontario to a point inside the canyon of Niagara, since reflooded and drowned 180 feet by the subsequent north-eastward tilting of the region.

REVIEWS.

I.—A Text-Book of Geology. By Philip Lake, M.A., F.G.S., and R. H. Rastall, M.A., F.G.S. 8vo; pp. xvi, 494, with 32 plates and 134 text-illustrations. London: Edward Arnold, 1910. Price 16*s*. net.

THIS volume, issued as one of "Arnold's Geological Series" under the general editorship of Dr. Marr, is of larger dimensions than the series in course of publication on Economic Geology. As a text-book it will occupy an appropriate position between the *Geology for Beginners* of Professor Watts and the two-volume textbook of Sir Archibald Geikie. In the first part Mr. Rastall gives a clear and concise account of the principles of the science as illustrated by agents now at work; he describes rock-structures and earth-movements, and gives special petrological descriptions of the igneous rocks, of metamorphism, ore deposits, and mineral veins, occupying in all 279 pages. In the remaining portion, also admirably executed, Mr. Lake deals with the principles of stratigraphy, and with the fauna and flora of the great geological systems.

The book is well printed, admirably illustrated, and it has a good index; above all, it is written by two experienced workers and teachers, who have brought before us the latest results of geological research. Few references, however, are given to authorities.

The student will welcome the exposition of rock-structures, of folds, and the formation of overthrusts, the treatment of earth-sculpture and of the agents of denudation, attention being called to the dominant action of particular agents of weathering, transport, and corrosion under different climatic conditions and in different latitudes.

The development of rivers is explained in diagrammatic form, but the student has to bear in mind that the actual river-courses are liable to almost endless modification, according to the structure of the ground, the nature of the rocks, the effects of subsequent uplift and adjustment, and the changes caused by the denudation of strata that conceal old topographical features. Attention is drawn to the variations of slope that arise in the course of a stream during the process of grading before it has reached the base-line of erosion. The term *thalweg* is said to be generally employed "to express the course of a stream considered in a vertical plane". By Mr. C. S. Slichter (Water-Supply Papers No. 67, U.S. Geol. Survey) the term is applied to the lowest line of drainage in a valley including not merely the surface flow but "the underground current, in general coincident with the thalweg", and the opinion is quoted "that the subterranean thalweg on the main line of underground drainage is usually nearer the steeper side of the valley than is the surface stream".

A good picture of the Sphinx illustrates the rounding and etching produced by wind-blown sand. Useful explanations are given of the words *dreikanter*, *zeugen*, etc., employed by some geologists, although the burdening of science with such technical terms, when 'facetted pebbles' and 'tabular outliers' should be sufficient, is somewhat pedantic and ill calculated to advance knowledge.

The pictorial plates have been well chosen, and they include many effective views of rock-structures, joints in igneous rock, strain-slip cleavage (from the Geological Survey), vertical strata, glaciers and glacial phenomena, natural arch and stacks, volcanoes and volcanic phenomena (including the 'spine' of Montagne Pelée), Tertiary basalt dyke, etc. The plates all illustrate Mr. Rastall's portion of the volume.

Mr. Lake commences with a philosophic essay on the principles of stratigraphy and on the methods of correlation. By means of instructive diagrams he shows the theoretical distribution in space and time of a species, from what would in old days have been termed a 'centre of creation'; but, as the author remarks, "many species had no definite beginning and no definite end, and their vertical ranges accordingly are also ill-defined." Species with a wide range were usually held to have a corresponding duration of time, but this does not apply to all forms, and those of zonal value "must belong to a group in which evolution is proceeding rapidly".

From the Pre-Cambrian or Archæan, in upward succession, the author describes the main characters and subdivisions of the great geological systems, and with the aid of maps points out their distribution in the British Isles. The more important facts are clearly laid before the reader without much detail; thicknesses of strata and economic products are not dealt with, unless incidentally. The fauna and physical conditions, the characteristic fossils and zones of the different formations, are the chief subjects.

The Devonian Series of North Devon and West Somerset is illustrated by Etheridge's map of 1867—essentially a diagram—and, as Mr. Lake admits, so far as our present knowledge goes, there is definite palæontological evidence that the Morte Slates are Lower Devonian.

We are glad to observe that the author has been bold enough to adopt the more widely accepted and common-sense Ammonite zones in the Jurassic and Cretaceous systems, and in consequence we read of the zones of *Ammonites Parkinsoni*, *A. perarmatus*, *A. varians*, etc., instead of being bewildered by a succession of new generic names, which vary to some extent in every textbook. The same plan was wisely adopted by Mr. H. Woods in 1907 in his Catalogue of the Fossils in the students' stratigraphical series at the Sedgwick Museum. Moreover, we are glad to note the rightful application of the term Bathonian to the Great Oolite Series, and that of Bajocian to the Inferior Oolite Series.

In dealing with the Pliocene Series the subject is illustrated by Mr. Harmer's map of the successive stages of the Crag divisions; and in reference to the Pleistocene Series the map of S. V. Wood, jun., showing the distribution of the Boulder-clays of the East of England, is inserted. To this map Mr. Harmer has added arrows to indicate the flow of the ice-sheets. This is the more important as Mr. Lake himself has adopted a somewhat negative attitude with regard to the origin of Boulder-clay in general. The subject is, however, treated very briefly, and the same may be said of the Post-Glacial Series, Palæolithic and Neolithic times being dealt with in a couple of pages.

In a final chapter Mr. Lake gives a useful summary of the great physical changes that have characterized the geological history of the British Isles.

II.—The Geology of Building Stones. By J. Allen Howe, B.Sc., F.G.S. 8vo; pp. viii, 455, with 8 plates, 7 maps, and 31 text-illustrations. London: Edward Arnold, 1910. Price 7*s.* 6*d.* net.

THIS is the fourth volume in "Arnold's Geological Series", edited by Dr. J. E. Marr, works on Coal and Coal Mining, Ore Deposits, and Water Supply having already been published. A comprehensive book on building-stones has long been wanted, as in this country since 1872, when Professor Hull's volume on *Building and Ornamental Stones* was published, we have had to depend mainly on the more or less scattered geological information given in sundry Geological Survey Memoirs, on the work of D. C. Davies on Slate, on that of G. F. Harris on Granites, and on the four excellent chapters in Dr. J. V. Elsden's *Applied Geology*, pt. ii, 1899.

Before settling down to the severer portions of his work, Mr. Howe gives a pleasant sketch of the influence of geology on the characters of the buildings in Britain, and on the aims and limitations of his work. Ornamental stones are dealt with but incidentally, as in references to Napoleonite, Luxullianite, the Norwegian 'Pearl' (augite-syenite), and various kinds of marble which, as in the case of the Devonshire limestones, are largely used for building purposes.

After contributing a useful chapter on minerals, the author takes up the subject of rocks, dealing first with the various granites and greenstones, then with sandstones, grits, conglomerates, and breccias, and their cementing materials, with limestones (calcareous and magnesian), with slates and stone-tiles, and with sundry miscellaneous building materials, such as flint and artificial stone. Then follow important chapters on the decay, preservation, and testing of building-stones, appendices on quarries, a list of some useful books, and an excellent index.

While the bulk of the work is rightly taken up with descriptions of British building-stones, their lithological characters, chemical and physical properties and distribution, there are also descriptions of the leading rocks used for building purposes in various parts of the world. The general distribution of the rocks in Britain is shown on the series of maps, and the structure of many of them is well depicted on plates from photomicrographs. The illustration of the weathering of Portland Stone is also excellent. Attention is given to the adaption of particular rocks to different purposes and in diverse situations, and mention is made of buildings constructed of the more important freestones and other materials. A little more might have been said with advantage about quarry-water and the seasoning of stone, and of the use of the term freestone.

A few statements and some names of places require emendation; thus the Clipsham Stone (p. 218) comes from Rutlandshire (not Oxfordshire), as may be inferred from previous references to it, while the Taynton Stone (p. 238) was quarried near Burford in Oxfordshire, though not far from the borders of Gloucestershire. The reference on p. 429 should be to Taunton.

The author has evidently devoted great pains to render his work as complete as possible, although the limitations of space have unfortunately prevented references to particular sources of information; but he has demonstrated by his careful record of facts and by his lucid explanations how much of scientific and practical interest, as well as importance, may be learnt from the geological study of building-stones.

III.—The Geology of the Country around Nottingham. By G. W. Lamplugh, F.R.S., and W. Gibson, D.Sc. London: printed for H.M. Stationery Office, and sold by E. Stanford, Long Acre, and T. Fisher Unwin, Adelphi Terrace. 8vo; pp. vi, 72, with 6 photographic plates, 1 sheet of sections, and 9 text-illustrations. 1910. Price 2*s.* Special colour-printed map, price 1*s.* 6*d.*

FOR the benefit of students in important educational centres the Geological Survey has issued special maps when the town or city happened to come near the margin of the ordinary (New Series) 1 inch sheets. London (as noted in our December Number) required four sheets. Oxford, and now Nottingham, have been given special sheets, while places like Cardiff, Swansea, and Southampton come within the central portions of the ordinary sheets. Among the New Series sheets Plymouth might advantageously be represented on a special sheet.

The memoir before us is made up of Sheets 125, 126, 141, and 142, already described in four memoirs, but the object now is to give a more general account of the geology, with less detail. It is rather curious to note that the usual chapter on economic geology is omitted, because "the map and present memoir are intended primarily to serve the requirements of Nottingham as an educational centre"; but would not most of the students who take up geology as a serious pursuit probably do so with the view of gaining their livelihood as mining engineers, geological surveyors, or teachers, and require some knowledge of the applications of geology? As pointed out, they will have the opportunity of purchasing the four memoirs already mentioned, and in the present work they may gather information about the structure of the coal-field, the sequence of the coals, and the organic remains which mark horizons. References are also given to the moulding-sands in the Bunter and to the gypsum in the Keuper, as well as to brick-clays.

As an exposition of the main geological features, of the palæontology and physical history of the formations, the work is excellent; and the illustrations of the Trent Valley at Nottingham during the flood of 1875, of the Magnesian Limestone Series near Kimberley, and of the Crags of Nottingham Castle, are particularly good.

The formations included in the area extend from the Millstone Grit to the Lower Lias, with Glacial Drift, River Gravels, and Alluvium. Attention is finally directed to subjects on which further information is needed, and to these the student, bent on research, may profitably devote his spare time. It is noteworthy that no palæolithic implements have been obtained in the district.

IV.—The Geology of the Country around Alresford. By H. J. Osborne White, F.G.S. London: printed for H.M. Stationery Office, and sold by E. Stanford, Long Acre, and T. Fisher Unwin, Adelphi Terrace. 8vo; pp. iv, 102, with 15 text-illustrations. 1910. Price 2*s.*

We welcome another memoir by Mr. Osborne White, the previous one on the Geology of Basingstoke having been noticed in the Geological Magazine for February, 1910. As before, the author, while adding considerably to our knowledge, has dealt carefully and generously in the text with the work of other observers, and of these Gilbert White will ever be most intimately associated with the district.

The area which is included in Sheet 300 of the colour-printed Geological Survey map lies directly south of that of Basingstoke, and Alresford is situated a little to the west of the central portion.

The formations that appear at the surface extend from the Weald Clay to the Reading Beds, and comprise sundry superficial deposits. There are no deep borings to indicate how far westwards the Lower Cretaceous strata may extend. The Weald Clay appears in a portion of Sussex, in the south-eastern corner of the area; thence westwards, as shown in the longitudinal section on the map, we cross the bold hills of Lower Greensand, the Gault vale, the gentle scarp of Upper Greensand, and the Chalk escarpment. While the name Selbornian was appropriately taken as a chronological division for the Upper Greensand and Gault, the map shows the importance of separating the two formations.

The author gives detailed accounts of all the subdivisions, of their fossils and economic products. In the Lower Greensand the Bargate Beds occur in the upper part of the Hythe Beds, below the Sandgate

Beds, although near Godalming and Guildford, where that clayey division is not recognized, the Bargate Beds have been grouped by some geologists with the Folkestone Beds.

The palæontological zones in Gault and Upper Greensand are dealt with as fully as possible, the zone of *Hoplites lautus* not being distinguished from that of *H. interruptus*, and that of *Pecten asper* not being clearly established. The Chalk zones are fully represented up to that of *Actinocamax quadratus*, and there is a good tabular list of all the fossils.

Only one outlier of Reading Beds has been observed near East Stratton, and there an imperfect section shows about 10 feet of sand and loam, with pebbly basement-bed and a covering of Clay-with-flints.

Greywethers occur in various places, some pebbly, and the author remarks that "There appears to be no good grounds for referring any of the local sarsens to the Reading Beds". On the other hand, it may be said that there are no good grounds for not regarding them as derived from that formation.

The author has given careful attention to the tectonic structure and the system of gentle folds, the principal and minor anticlines and synclines being shown on a sketch-map. These have influenced the topography indirectly, and their relation to the various streams and rivers is briefly discussed.

With regard to the Clay-with-flints the author observes that while it is largely made up of debris of Reading Beds, "it rests indifferently on surfaces which may be four or five feet, or four or five hundred feet, below the Eocene basal plane," and "may be said to be in process of formation at the present day" under the solvent action of rain. He agrees with Mr. Jukes-Browne "that much of this deposit, in its present form, is a result of vigorous soil-cap movement, occurring under sub-arctic conditions, during late Pliocene and early Pleistocene times".

Three small patches of stony sand and loam 370 to 390 feet above Ordnance Datum occur on the Gault in the north-eastern part of the area; and these, the only representatives of 'Plateau Gravel', in the opinion of the author "may be correlated with the Palæolithic deposits of Farnham Common", further to the north-east.

The River Gravel, Rain-wash, and Alluvium are described, and there is an interesting chapter on Economic Geology. Remarks are made on the soils and land dressing, there being a marked connexion between the soil and subsoils, and the agricultural features. Building and road materials, springs and water-supply also receive attention.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

1. *December* 21, 1910.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Keuper Marls around Charnwood Forest." By Thomas Owen Bosworth, B.A., B.Sc., F.G.S.

The area under consideration comprises some 300 square miles, including the towns of Leicester, Loughborough, Coalville, and Hinckley. As has been shown by Professor Watts, the Charnian rocks project through a mantle of Triassic deposits which once completely covered them. In numerous quarry-sections the relation of the Keuper to the pre-Cambrian rocks is well exposed.

The quarries generally have been opened in the summits of the more or less completely buried hills. A quarry is so worked that its outline follows the contour of the buried hill; consequently, the section presents but a dwarfed impression of the irregularity of the rock-surface. Nevertheless, considerable undulations are observed, and wherever there are any sections at right angles to the contours, the rock-slopes are seen to be remarkably steep. Contoured maps have been prepared, showing the features of some of these covered peaks.

On the buried slopes and in the gullies are screes and breccias, and bands of stones and grit are present in the adjacent beds of marl. All these stones, in every case, are derived only from the rock immediately at hand. They never resemble pebbles, but often are fretted into irregular shapes. Where exposed to the present climate, the Charnian igneous rocks are deeply weathered and disintegrated. But the same rocks beneath the Keuper are fresh right up to the top, as also are the rock-fragments in the marls.

The Keuper marls lie in a catenary manner across the gullies, and probably across the large valleys also, for they dip away steeply in all directions around each buried peak.

There has been almost no post-Triassic movement in Charnwood. Nevertheless, the beds must have been originally laid down horizontally, for they are in no way peculiar, and contain the normal seams of shallow-water sediment. All the points of contact of any one bed with the Charnian rocks lie on one horizontal plane. The inclination of the strata must, therefore, be due to subsequent sagging.

The Upper Keuper deposits accumulated in a desert basin, of which parts were dry and parts were occupied by ever-shifting salt lakes and pools. In these waters the red marls were laid down. The red marls are of several different types, and are usually well-bedded. The principal ingredients are a certain aluminous mineral in very small particles and a much smaller proportion of very fine quartz-sand. There is generally 20 or 30 per cent. of dolomite present, in the form of minute rhombs.

The grey bands include various kinds of rock. Each band usually contains one or more seams of well-bedded sandstone or quartzose dolomite, and may safely be relied upon to indicate the bedding. The irregularities are due to irregularity in the bleaching above and below these porous seams.

The abundant heavy minerals are garnet, zircon, tourmaline, staurolite, rutile, magnetite. These are found in every sediment—marls, sandstones, grits, breccias, etc. The grains are intensely worn.

The quartz-grains are sometimes evidently wind-worn. The sand in the grey bands is coarser and more abundant than that in the red marls. Each grey band marks the introduction of coarser sediment into the basin. The false bedding is mainly from the south-west.

The bands are of wide extent and are due to inflows of fresh water from the surrounding hills, which from time to time spread themselves far and wide over the dry portions of the desert, and were often completely desiccated before reaching any pre-existing pool. Where these waters evaporated the quartzose-dolomite seams were formed, bearing ripple-marks and salt-pseudomorphs. The ripples indicate prevalent south-westerly winds.

2. "The Relationship of the Permian to the Trias in Nottinghamshire."[1] By Robert Lionel Sherlock, B.Sc., A.R.C.Sc., F.G.S.

In South Northamptonshire the Permo-Trias consists of the following divisions:—

KEUPER . .	Marls. Waterstones.
BUNTER . .	Pebble Beds. Lower Mottled Sandstone.
PERMIAN . .	Middle Marl. Lower Magnesian Limestone. Marl Slates and Breccia locally.

The conformability or unconformability of the Bunter to the Permian has been much discussed, but it is generally considered that there is a small unconformity between them. The evidence for this is the appearance of an Upper Magnesian Limestone, and locally an Upper Marl, between the Middle Marl and the Bunter, as the beds are followed northwards, so that the Bunter appears to overlap the Permian divisions from north to south.

In this paper a section on the Great Central Railway, near Annesley, is described, which shows a gradual passage from the Middle Marl into the Lower Mottled Sandstone. Detailed mapping on the 6 inch scale between Nottingham and Market Warsop has confirmed this conclusion.

From Nottingham to Mansfield the Middle Marl retains a uniform character and thickness, but at Mansfield it is apparently absent, and the Bunter has been thought to overlap it and rest directly on the Lower Magnesian Limestone. At the same place the limestone becomes very sandy, forming the Mansfield Sandstone. It is shown that these two phenomena can be best explained by supposing that a river deposited a sand-bar at Mansfield during Permian times, so that the limestone was replaced by sandstone, as was also, later, the Middle Marl. The sandy representative of the Middle Marl has been mistaken for Bunter, and so given rise to the appearance of an overlap.

North of Mansfield the Middle Marl becomes normal again. Near Cuckney the Upper Magnesian Limestone first appears as a very thin bed, and evidence is brought forward to show that the limestone arises as thin lenticular bands in the Passage Bed, which develop northwards into a definite bed. In precisely the same way sandstone lenticles in the marl in South Nottinghamshire develop into a definite bed of sand-rock, called the Lower Mottled Sandstone. At first a thin Upper Magnesian Limestone is found below a diminished representative of

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

the Lower Mottled Sandstone; but, on following the outcrop northwards, the Upper Limestone is seen to grow in importance and the Lower Mottled to diminish, until, in South Yorkshire, it is not found.

The Permian rocks continue to increase in thickness and the Bunter to diminish, until the Pebble Beds also become unrecognizable, in North Yorkshire. Also the Middle Marl now fails, and a thick mass of limestone remains to represent the Permian. The Keuper Waterstones persist throughout, and seem to be slightly unconformable to the Bunter.

From these considerations it is believed that the Upper Magnesian Limestone and Upper Marl of the northern part of the outcrop are the time equivalents of the Bunter of South Nottinghamshire, the one being deposited in an inland sea, comparable with the Caspian, the other along the coastline, which was slowly moving northwards.

The palæontology of the Upper Magnesian Limestone is discussed, and the evidence derivable from the fossils is shown to be not unfavourable to the above view.

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2. *January* 11, 1911.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Zonal Classification of the Salopian Rocks of Cautley and Ravenstonedale." By Miss G. R. Watney and Miss E. G. Welch. (Communicated by J. E. Marr, Sc.D., F.R.S., F.G.S.)

The district described lies north-east of Sedbergh and west of the Dent Fault. An account of the literature treating of previous work is given, and the succession of the zones is described. They are as follows:—

Lower Ludlow.	D 3.	Zone of	*Monograptus leintwardinensis.*
	D 2.	,,	*M. nilssoni.*
	D 1.	,,	*Phacops obtusicaudatus.*
Wenlock.	C 4.	,,	*Cyrtograptus lundgreni.*
	C 3.	,,	*C. rigidus.*
	C 2.	,,	*Monograptus riccartonensis.*
	C 1.	,,	*Cyrtograptus murchisoni.*

Below are Valentian rocks (A and B divisions of the Stockdale Shales).

The Wenlock Beds are most fully developed in some streams entering the River Rawthey from the south. The detailed succession of these is given, and confirmatory sections are described in other parts of the district.

The Ludlow Beds are found mainly in the northern part of the area, where the geology is simpler.

A comparison is instituted between these beds and those described in the Welsh Borderland by Miss Elles & Miss Wood (Mrs. Shakespear), and those of Wenlock age in Southern Sweden described by Tullberg.

CAUTLEY.	WELSH BORDERS.	SOUTHERN SWEDEN.
Zone of *Monograptus leintwardinensis.*	Zone of *M. leintwardinensis.*	
Red grits and flags, ? =	,, *M. tumescens.* ,, *M. scanicus.*	
Zone of *Monograptus nilssoni.*	,, *M. nilssoni.*	
,, *Phacops obtusicaudatus*, ? =	,, *M. vulgaris.*	
,, *Cyrtograptus lundgreni.*	,, *C. lundgreni.*	Zone of *C. carruthersi.*
,, *C. rigidus.*	,, *C. rigidus.* ,, *C. linnarssoni.* ,, *C. symmetricus.*	,, *C. rigidus.*
,, *Monograptus riccartonensis.*	,, *M. riccartonensis.*	,, *M. riccartonensis.*
,, *Cyrtograptus murchisoni.*	,, *C. murchisoni.*	,, *C. murchisoni.*

A description of a *Cyrtograptus* intermediate in character between *C. rigidus* and *C. symmetricus*, and of a new *Monograptus* from the *Nilssoni* Beds of Wandale Hill, is given in a palæontological section.

2. "On a Collection of Insect-Remains from the South Wales Coalfield." By Herbert Bolton, F.R.S.E., F.G.S., Curator of the Bristol Natural History Museum.

The author describes nine examples of insect-remains, all being, with one exception, blattoid in character. Seven are described as new species. Six of the specimens were obtained from the horizon of the Mynyddislwyn Vein and Swansea Four-Foot Seam; two from shales associated with the Graigola Seam, and a 22 inch seam occurring 40 yards below it; while one specimen was found in shales associated with the Rhondda No. 2 Seam, and therefore on the same horizon as the example of *Etoblattina* (*Archimylacris*) *woodwardi*, Bolton, previously described by the author in the GEOLOGICAL MAGAZINE for 1910, p. 147.

The whole of the insect-remains are referable to three horizons—one at the base of the Upper Series of the Coal-measures, and two in the upper part of the Pennant Series. Two indeterminate species are referred to the genus *Archimylacris*, two to *Hemimylacris*, one to *Archimylacris* (*Schizoblatta*), one to *Archimylacris* (*Etoblattina*), one to *Gerablattina* (*Aphthoroblattina*), one to *Orthomylacris*, and one to *Lamproptilia*. The last-named genus is new to the British

Coal-measures. Attention is drawn to the association of the blattoid remains with *Cordaites* leaves bearing the impressions of the tests of *Spirorbis pusillus*. The suggestion is put forward that possibly Carboniferous cockroaches were not only phytophagous in habit, but frequented decaying *Cordaites* leaves in order to feed upon the *Spirorbis*.

The presence of Archimylacrid and Orthomylacrid forms, no less than the presence of a species of *Lamproptilia*, is considered indicative of a considerable advance in insect development in the British Carboniferous beyond the more primitive palæodictyopteran types; while their abundance in the Pennant and Upper Series of the South Wales Coal-field may justify the hope of finding more primitive forms at a lower horizon in the same coal-field. Their occurrence may also be indicative of the remains of a terrestrial fauna somewhere in the South Wales Coal-measures.

The President announced that at 7 p.m. on Wednesday, January 25, 1911, a Special General Meeting would be held, in order to consider the following Resolutions of Council:—

(*a*) That the space now occupied by the Museum be made available for the extension of the Library.

(*b*) That it is desirable that the Society's collections of Fossils, Minerals, and Rocks, with certain exceptions to be subsequently specified, be offered to one or more of the National Museums, provided that guarantees be obtained that the specimens will be properly registered and rendered available for scientific purposes.

(*c*) That it is not desirable that the Society should accept money for any part of the collections, or in consideration of them.

(*d*) That the Council be empowered to approach such Institution or Institutions with a view to carrying the above resolutions into effect, and that the Council shall call another Special General Meeting to express approval or otherwise of the arrangement proposed.

II.—Edinburgh Geological Society.

December 21, 1910.—Dr. Horne, F.R.S., in the Chair.

The following paper was read:—

"The Carboniferous Rocks and Fossils in the Neighbourhood of Pitscottie, Fifeshire." By R. M. Craig, M.A., B.Sc., Assistant in the Geological Department, The University, St. Andrews, and David Balsillie, Student of Science, The University, St. Andrews.

The authors described a section of Carboniferous strata exposed in Kininmonth Den, near Pitscottie, Fifeshire. These consist of sandstones, shales, and limestones, some of which are richly fossiliferous. The most striking feature is the occurrence of well-marked bands of limestone charged with true marine fossils, comprising corals, brachiopods, polyzoa, and lamellibranchs, which elsewhere are characteristic of the Lower Limestone group of the Carboniferous Limestone Series. On physical and palæontological grounds, the authors suggest that the beds in this stream section ought to be grouped with these lower limestones rather than with the Calciferous Sandstone Series as mapped by the Geological Survey. The authors showed a suite of fossils in illustration of the paper.

CORRESPONDENCE.

HIGH-LEVEL SHELLY DRIFT.

Sir,—Mr. Crook (Geol. Mag., January, 1911) is wrong in supposing that the upholders of the land-ice hypothesis for the origin of our high-level shelly drifts are satisfied by the rendering of their views as usually stated by the opponents of the hypothesis, and he credits them undeservedly with docility in the matter. As only one of the upholders in question I venture to refer Mr. Crook to a letter of mine in *Nature* for May 6, 1897 (vol. lvi, p. 10), which displays a really deplorable lack of docility. Since that was written I have repeatedly set forth the full argument, in a more subdued tone, in applying the hypothesis to specific instances—e.g., in memoirs on the Isle of Man, on the Dublin district, on the Belfast district, and in an address to Section C of the British Association, York, 1906—referring in the last, among other instances, to observations in North Greenland even more illustrative than that to which Mr. Crook draws attention. Finally, last summer, in Spitzbergen, I saw for myself some remarkable examples of the entanglement and uplift of marine detritus by glaciers and its incorporation with the morainic products of land-ice.

It has been persistently explained that our *high-level* shelly drifts are believed to represent, not a bodily transportation of their material *en masse*, but an uplifting and scattering of the marine detritus piecemeal by the advancing ice-sheets. Statement of the case has of late grown wearisome even to its upholders by unavailing reiteration, and the misapprehension which has impressed Mr. Crook will no doubt continue to reveal itself from time to time as blandly as ever.

G. W. Lamplugh.

St. Albans.
January 7, 1911.

MISNAMED LOCALITIES AND THE *UINTACRINUS* CHALK AT KESTON.

Sir,—In September last you kindly published a letter from me respecting the discovery of the Marsupite zone at Farnborough in Kent. By some accident this appeared as *Marsupites* in Surrey, which zone had been worked by Mr. George Young, F.G.S., and described by him in the Proceedings of the Geologists' Association. I did not see the letter for a long time after its publication, or should have written at once to correct the error.

In October last, while examining the chalk by the roadside immediately opposite Keston Church, where about 18 inches of it are revealed above the footpath, I discovered ample proof of the presence of the *Uintacrinus*-zone, which I had previously discovered at Orpington, Fox Hill, and West Wickham. The great point of interest attached to this is that the fauna revealed in the Leave's Green Pit a few yards south of Keston Church is that of the

Micraster cor-anguinum-zone, and, as I have stated elsewhere, is identical with the Northfleet, Gravesend, Dartford, Farningham Road, and Foot's Cray Chalk, so that we now know that the topmost beds of this zone mark the whole of this area, the *Uintacrinus* and Marsupite zones having been denuded.

While dealing with this subject it may not be inappropriate to give some information respecting the fossils in the British Museum and elsewhere labelled "Bromley" as regards locality. For many years I tried to solve this mystery, not being aware of any outcrop of Chalk in that district. My friend Mr. Watson, of the Catford Natural History Society, has kindly sent me the following:—*History of Chislehurst*, by E. A. Webb, p. 338: "From these now disused chalk-pits along the base of Camden Hill large numbers of fossils have been obtained from time to time. The locality, however, has generally been quoted as Bromley. There is a magnificent series of Echinoderms from this parish in the Natural History Museum, South Kensington, several of the examples being 'types'."

The pits are situated at the back of Willett's Mews; there is a drawing of them by Mr. Whitaker in his *Geology of London*, vol. i. The ecclesiastical boundary of Bromley may extend to this pit, hence the confusion which has arisen. The Mews is situated immediately at the bottom of the hill on turning to the left after leaving the 'down side' of Chislehurst Station.

G. E. Dibley.

Sydenham, S.E.
January 16, 1911.

MISCELLANEOUS.

Geological Survey of India.—Sir Henry Holland, K.C.I.E., F.A.S., came home on furlough from India in the autumn of 1909, leaving his colleague, Mr. T. H. D. La Touche, F.G.S., for the time in charge as acting Director. Both gentlemen having now retired from the Indian Service, Mr. Henry Hubert Hayden, B.A., B.E., F.G.S., has been appointed to succeed to the post of Director of the Geological Survey of India. Mr. Hayden joined the Department on January 3, 1895, and has seen service in most parts of India and Burma. He is, however, best known for his survey of Spiti in the Central Himalayas of the Punjab, and for his work on Eastern Tibet. Since the publication of these two important memoirs he has spent some time in Afghanistan, the results of his work being now practically ready for publication.

Two Assistants have been recently appointed to complete the Staff of the Indian Survey; namely, Mr. H. S. Bion, B.Sc., who has been an Assistant to Professor E. J. Garwood at University College, London; and Mr. C. S. Fox, B.Sc., Lecturer on Mine Surveying in the Birmingham University.

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ASSISTED BY

PROFESSOR J. W. GREGORY, D.Sc., F.R.S., F.G.S.

DR. GEORGE J. HINDE, F.R.S., F.G.S.

SIR THOMAS H. HOLLAND, K.C.I.E., A.R.C.S., D.Sc., F.R.S., F.G.S.

PROFESSOR W. W. WATTS, Sc.D., M.Sc., F.R.S., PRES. GEOL. SOC.

DR. ARTHUR SMITH WOODWARD, F.R.S., F.L.S., SEC. GEOL. SOC., AND

HORACE B. WOODWARD, F.R.S., F.G.S.

MARCH, 1911.

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R. Lunn photo.

View looking west from near Port a' Chotain, 2 miles west of Rhuvaal, Islay, showing the preglacial platform of marine erosion overlain by gravels of the postglacial 100-foot beach. In the foreground the grassy platform of the 25-foot beach. To the right on the shore a modern storm-beach of white quartzite shingle. In the distance the Mala Bholsa.

THE

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No. III.—MARCH, 1911.

ORIGINAL ARTICLES.

I.—On a Preglacial Shoreline in the Western Isles of Scotland.

By W. B. Wright, F.G.S.

(PLATE VI.)

THE preglacial[1] platform of marine erosion discussed in the following pages was first discovered in the Island of Colonsay in the course of the geological survey of that island carried out in the summer of 1907, and the information then acquired is communicated with the permission of the Director of the Survey. The subsequent tracing of the shoreline in the adjoining islands was effected with the aid of a Government grant for scientific research in the gift of the Royal Society of London. For clearness and convenience of reference the subject will be treated under the following heads:—

I. Introductory remarks indicating the aims of the investigation.
II. Colonsay and Oronsay—description of the preglacial platform.
III. Islay.
IV. Mull and Iona.
V. The Treshnish Islands.
VI. Conclusion, setting forth the present state of the subject.

I. Introduction.

In the isostatic problems connected with the Ice Age the determination of the preglacial sea-level is of primary importance. It is a datum to which subsequent oscillations of the shoreline may be referred, and as such affords a criterion for the discrimination of temporary and permanent deformations of the crust. A permanent glacial or postglacial deformation must show itself as a difference in level between the preglacial and present shorelines. On the other hand, a temporary oscillation, if complete, leaves no record of this kind, although it may be readily demonstrable in other ways. Now in the British Isles there is abundant evidence of both glacial and postglacial oscillations, and it is obviously important to determine to what extent the displacements effected have been temporary or permanent. The tracing of the preglacial shoreline has therefore in this respect a very special interest, and if successfully carried out might ultimately lead to the establishment or rejection of Jamieson's isostatic theory of the quaternary oscillations of sea-level.[2]

[1] Interglacialists will excuse the use of this term in the sense of prior to the only apparent general glaciation of the district in question.

[2] T. F. Jamieson, "On the History of the Last Geological Changes in Scotland": Quart. Journ. Geol. Soc., vol. xxi, p. 178, 1865.

Now the preglacial shoreline of the southern half of the British Isles has for some time past been fairly well known. Indeed, in the districts outside the glaciated area it has been the subject of papers from the very earliest days of geology, but its preglacial age was not at first recognized. It was not until Mr. Lamplugh[1] in 1888 described the buried cliff and beach beneath the drifts of Flamborough Head in Yorkshire that the first clue in this direction was obtained. From Yorkshire to the south coast of England, however, is a long cry, and the correlation was not readily made. In 1900, however, Mr. Tiddeman[2] showed that this shoreline of the south coast, which had been found also along the shores of the Bristol Channel, could be traced in South Wales beneath the boulder-clay, and he thus clearly established its preglacial age. Mr. Lamplugh[3] next proved its existence in the Isle of Man, and subsequently its presence was established along the whole south coast of Ireland and up the east coast as far as Dublin.[4] More recently it has been detected in Clare by the present author,[5] and in Kilary Harbour, county Mayo, by Messrs. Maufe & Carruthers.[5] Mr. Fearnsides[6] has also quite recently proved it to occur in Carnarvonshire in North Wales.

Thus it will be seen that in those portions of the British Isles lying south of a line through Yorkshire, the Isle of Man, and Mayo we are already well acquainted with the level of the preglacial sea, and it is remarkable that this level is almost coincident with the present sea-level. Throughout the greater part of this district it stands uniformly some 10 or 12 feet above the present high-water mark, and maintains a remarkable parallelism with the present shore. This parallelism proves almost beyond a doubt that no marked permanent deformation by folding or faulting has taken place over this wide area since preglacial times. It would perhaps be safer to qualify this statement somewhat and to say instead that if any such deformation has occurred within the area it is entirely exceptional and local. We have, however, no definite indication of any displacement of the kind, and, even if such did occur, it cannot affect the conclusion that has just been drawn regarding the general stability of the region.

Now throughout this apparently stable district there occur submerged forests and peat beds often at a considerable depth below sea-level. The oscillation which allowed of their formation we must therefore regard as temporary, at least in the sense that the sea has

[1] G. W. Lamplugh, "Report on the Buried Cliff at Sewerby": Proc. Yorkshire Geol. and Polytec. Soc., vol. ix, pp. 382–92, 1889, and Rep. Brit. Assoc. for 1888. See also "Drifts of Flamborough Head": Quart. Journ. Geol. Soc., vol. xlvii, p. 394, and Proc. Yorks. Geol. and Polytec. Soc., vol. xv, pp. 91–5, 1903.

[2] R. H. Tiddeman, "On the Age of the Raised Beach of Southern Britain as seen in Gower": Rep. Brit. Assoc., 1900, p. 760.

[3] G. W. Lamplugh, "Geology of the Isle of Man," p. 14: Mem. Geol. Surv. U.K., 1903.

[4] W. B. Wright & H. B. Muff (now Maufe), "The Pre-glacial Raised Beach of the South Coast of Ireland": Sci. Proc. Roy. Dublin Soc., vol. x (N.S.), pt. ii, p. 250, 1904.

[5] Descriptions not yet published.

[6] W. G. Fearnsides, "The Tremadoc Slates and Associated Rocks of South-East Carnarvonshire": Quart. Journ. Geol. Soc., vol. lxvi, p. 182, 1910.

since assumed a level differing but little from one which it occupied long before the oscillation took place. The further question as to whether the postglacial raised beaches[1] of the British Isles are in the same sense the result of temporary oscillations is not as readily solved. It would be quite unsafe to generalize from the one case to the other; for the raised beaches and submerged forests have this essential difference, that the latter are widely distributed phenomena, whereas the former are distinctly grouped round a centre in the Scottish Highlands. This centralization of the raised beaches indicates that the oscillations they record have a different cause from that of the submerged forests. This being the case, the tracing of the preglacial shoreline into the area occupied by the postglacial beaches assumes a double interest.

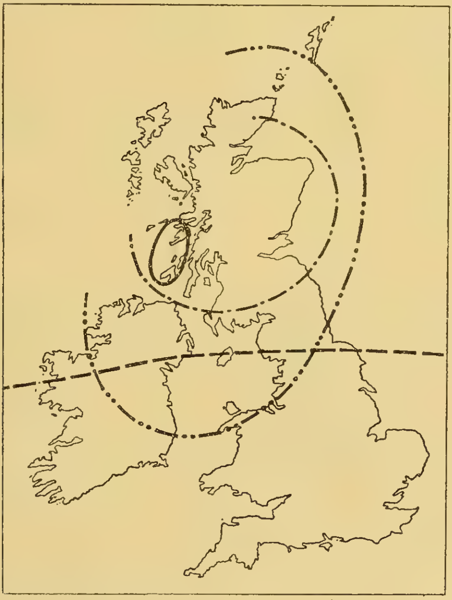


FIG. 1. Diagram to show the distribution of the various beaches as at present known.

———— Preglacial beach of the Western Isles of Scotland.
— — — Northern limit of preglacial beach of Southern Britain.
— · — · — 100-foot late glacial beach of Scotland.
— ·· — ·· — Post glacial, Neolithic beach, so-called 25-foot raised beach.

Up to the present, however, very little has been effected in this direction. Some significance may attach to the fact that the preglacial

[1] For the benefit of readers who do not happen to be acquainted with the subject it may be mentioned here that two distinct raised beaches are known in Scotland, namely, the 100-foot late-glacial beach (with probably associated shorelines at lower levels) and the 25-foot postglacial or Neolithic beach. Their periods of formation were separated by one of elevation in which submerged forests were found.

shoreline is slightly lower in Yorkshire and the Isle of Man than further south. In Yorkshire the inner angle of the preglacial platform lies a few feet above high-water mark, in the Isle of Man approximately at high-water mark. The former of these localities lies a short distance outside the area of distribution of the so-called '25-foot' postglacial raised beach, the latter fairly well within it. This may possibly be an indication that towards and within the area of the postglacial raised beaches the preglacial raised beach has suffered a depression from which it has not yet recovered.[1] Its apparent absence over the greater part of Scotland might therefore be due to its being entirely below sea-level and thus unobservable.

Recently, however, some discoveries in the Western Isles of Scotland have shown that the problem is a much more complex one than had formerly been supposed. Throughout an area embracing Islay, Colonsay, Mull, and the Treshnish Islands there is a pronounced and locally well-preserved shoreline of preglacial age at a height varying from 90 to 135 feet above sea-level. This rather startling disclosure has of course been the basis of many speculations, but it is doubtful if these have as yet any permanent value. The existence of the shoreline is, however, beyond question, as is also its preglacial age. We shall devote the succeeding paragraphs to an account of its development in the different islands, and conclude with some general remarks.

II. Colonsay and Oronsay.

The old plain of marine erosion can be traced throughout the greater part of Colonsay and Oronsay, and is one of the most remarkable physiographical features of the islands. It has suffered somewhat from glacial and perhaps also subaerial denudation, and large areas of it have been removed at various stages by the sea. Nevertheless here and there wide stretches are preserved, and it is possible in many places to trace its inner margin, which is frequently marked by a line of lofty cliffs.

A pronounced feature of the platform is the manner in which it is locally dissected by slacks and hollows. It is to be noted, however, that many of these may have pre-existed the cutting of the platform, and therefore do not necessarily represent the extent of subaerial and glacial erosion since its formation. If there has been any marked subaerial modification of the original form of the plain, which may well be doubted, it has clearly been effected in preglacial times, for the postglacial denudation has been very slight. One finds few or no hollows of obviously postglacial date, and the amount of atmospheric weathering since the Ice Age has also been quite trifling. Everywhere one finds the surface of the plain ice moulded, and in many places it is striated and covered by boulder-clay; the old line of cliff also frequently shows marks of the passage of the ice, and one cannot but be struck by the slight modification which these much exposed glaciated surfaces have undergone.

[1] As opposed to this, however, it should be noted that the scanty remnants of the preglacial platform found at Bray Head in Wicklow, which lies just within the area of distribution of the 25-foot beach, do not show any marked depression.

This remarkable rock-shelf and its accompanying cliffs are best preserved in Uragaig to the west of Kiloran Bay (see Fig. 2). The platform is here nearly half a mile wide, and probably once extended much farther seaward. Its inner angle beneath the magnificent cliffs of Tornach Mor is about 135 feet above high-water mark of ordinary spring tides. It can be traced from here round the west coast for about a mile and a half to Port Ban, forming along this coast the grassy platforms between the upper and lower cliffs known as Aonan Ceann a' Gharràidh, Aonan nam Bo, Aonan Mhic Mhuirtean, and Aonan nam Muc.[1] South of the last-named locality no sure trace of it can be found along the cliffs as far as the south side of Binnein Riabhach. Here a great strip of the platform can be seen stretching away inland towards Upper Kilchattan, although it is much denuded and its inner margin is ill defined. South of Port Mor, however, the old coastline is marked by a fine cliff forming the western faces of Beinn nan Caorach and Sliabh Riabhach. The pass to the south of the last-mentioned hill was a strait at the time of the formation of the old shoreline, and the platform can be traced right through it to Scalasaig along the north side of the road.

FIG. 2. Uragaig from the north side of Kiloran Bay, showing the cliff and rock-platform of the 135-foot preglacial raised beach.[2]

The higher parts of the southern half of Colonsay, with Beinn Oronsay, formed at this period outstanding islands with a series of

[1] Aonan means a grassy pasture open to the sea, and surrounded by rocky cliffs. It does not strictly imply "a step between the higher and lower cliffs", as stated by Mr. Symington Grieve, although it often is so. A small aonan, the Aonan nam Clach Mòra, north of the Cailleach Uragaig, is a grassy flat of beach gravel surrounded by cliffs and lying only a little above high-water mark. A former proprietor of the inn at Scalasaig, Mr. Donald M'Neill, being worried by his guests as to the meaning of Aonan nam Muc, translated it for their benefit as The Pig's Paradise, and by this name it has been commonly known since. To Mr. Grieve belongs the credit of having first recognized that some of the higher aonans along the west coast owe their origin to marine erosion; he does not, however, appear to have noticed that they are of preglacial age. See Proc. Soc. Ant. Scot., vol. v, p. 351, 1882–3.

[2] Figs. 2 and 3 are reproduced, by permission of the Controller of H.M. Stationery Office, from the Geological Survey Memoir on Sheet 35, Scotland.

narrow straits between (see Fig. 4). The platform of erosion among these islands is in a few places still well preserved, as on the plateau known as Lòn Mòr to the south-west of Loch Staosnaig. A distinct shelf can also be traced round Beinn Eibhinn, and it is again particularly well marked on the south side of Beinn Oronsay.

Some outlying hills in the north of Colonsay were also isolated, while the big inland cliffs south of Balnahard marked, at this stage, the coast of the main island.

On the east side of the islands the effect of full exposure to the impact of the ice is noticeable in the planing down of the platform and the rounding off of the old cliff feature. This is, of course, especially marked in the softer, more pelitic beds, but where the rock-shelf is cut in the harder grits, as in the case of some of the headlands north of Scalasaig, both cliff and platform are sometimes well preserved (see Fig. 3).

Fig. 3. The shores of Colonsay looking north from Port Olmsa, showing the preglacial cliff and rock-platform and the ice-planed slopes of the east coast.[1]

In addition to this well-marked high-level platform there exists another, first pointed out by Mr. Bailey, which lies a little above sea-level, and may perhaps also be taken as indicating a preglacial plain of marine denudation. This lower platform includes a considerable portion of the low-lying ground in Oronsay, and also the ice-worn skerries, many of them covered at high tide, which render the western coast so dangerous to navigation. There is also a suggestion that the fine sea-cliffs along the coast from Kilchattan north are not entirely postglacial. The evidence, however, for this lower preglacial plain is very poor, and little reliance can be placed on it. It rarely or never has a well-defined inner margin or a cliff that can be traced any distance. One point, however, which lends it some support should be mentioned here. A plain at a similar level has been observed in the Torridonian rocks on the east coast of Iona along the shores of the sound separating Iona from the mainland of Mull. This shelf is overlain by the gravels of the 25-foot beach, but it is clear that it does not belong to this beach, since there is no cliff at the back of it at all equivalent in magnitude to the extent of the plain, but instead a rounded ice-worn slope.

[1] See note 2, p. 101.

III. Islay.

Along the north-west coast of Islay between Loch Gruinart and the Rudh' a' Mhàil the preglacial platform of marine erosion has a very magnificent development. The relations here, however, are obscured, and have escaped the notice of former geologists owing to the fact that the rock-platform of the preglacial shore is everywhere overlain by the copious gravels of the postglacial 100-foot beach. The platform came thus to be regarded as the work of the 100-foot postglacial sea. Apart, however, from the fact that nowhere else has this sea been able to erode anything beyond the most trifling notch in rocks of the hardness of the Islay quartzite, there is ample evidence that the rock-platform is of much earlier date. The cliff at the back of the 100-foot beach is in many places composed of boulder-clay, and the rock-platform on which the gravels rest passes beneath this boulder-clay; while from behind the boulder-clay there rises again a steep hill face of rock, evidently the old cliff corresponding to the rock-platform. The boulder-clay thus lies packed into the angle between the cliff and the platform. Moreover, if we follow the present sea-cliffs, which show in section the outer portion of the platform capped by the 100-foot gravels, we find here and there between the gravel and the platform lenticles of boulder-clay which lie on slightly lower portions of the platform, and which have been planed off above by the action of the 100-foot sea.

Both these phenomena are well seen in the neighbourhood of the Mala Bholsa. Immediately north of the small stream which enters the sea south of this hill the gravel of the 100-foot beach rests on boulder-clay, which lies in a slight hollow of the preglacial platform. The matrix of the boulder-clay is here a quartzite meal of the nature of pasty sand, but the structure of the deposit leaves no doubt that it is boulder-clay. Also about 200 yards north-east of this the cliffs of the Aonan na Mala immediately below the Mala Bholsa show the following section:—

Angular gravel . . .	4 feet	100-foot beach deposits.
Stratified sand . . .	4 ,,	
Boulder-clay	7 ,,	
Rock-platform.		

A great mass of drift is banked up on the west side of the Mala Bholsa, and in the cliff of the Aonan na Mala the preglacial platform is seen passing horizontally beneath it. The great geo or sea-cut gully, which a little to the north runs up towards the Mala Bholsa, shows in section this remarkably even platform beneath the drift to within 30 yards of its junction with the cliff-slopes of the hill. Measurement with an Abney level from high-water mark of spring tides gave 105 feet as the level of the platform at the innermost visible point, i.e. about 30 yards from the rock-cliff. A hollow in it contains a small patch of quartzite rubble beneath the boulder-clay.

From the Mala Bholsa magnificent views can be obtained both to the south-west and east of this striking plain of marine erosion with its overlying but utterly unconnected sheet of postglacial beach-gravel.

On the west coast of the Oa of Islay some remnants of the preglacial platform are also preserved, although along the greater part of the coast it has been entirely removed by the recent encroachments of the sea. These remnants occur between Allt Tràigh Leacail and Lower Glen Astle, and also on Rudha Ruadh west of Maol an Fhithich. They are loaded with drift, so that no doubt can be felt as regards their age. The cliff behind is generally somewhat rounded off at the top. Measurement with an Abney level showed that the inner angle stands about 95 feet or so above high-water mark of spring tides.

IV. Mull and Iona.

In the districts already described it has been possible to demonstrate satisfactorily in every case the preglacial age of the rock-platform. In Mull, however, where it has its most persistent and remarkable development over long stretches of coast, this has been found extremely difficult. No boulder-clay has been found overlying the platform and no striæ have been observed on its surface. In a few cases only has it been possible to detect distinct ice-moulding on rocks which are undoubtedly portions of the platform, and these cases had to be sought for with some diligence. Even apart from the finding of these ice-moulded surfaces, however, there can be little doubt regarding the identity of the Mull platform. Its striking development, great width, and the imposing character of the cliff by which it is backed, make it impossible to refer it to the action of the postglacial sea, the cutting effect of which in other parts of Scotland has been comparatively trifling in amount.

The presence of the preglacial beach can be proved here and there along most of the west coast of Mull, but it forms a really striking feature of the scenery from Ulva and Gometra north to the Caliach Point in Mornish. In Gometra the platform is much dissected by hollows and geos, but the remnants of it preserve on the whole a fairly uniform level, and the old cliff behind is very well preserved. The inner angle is distinctly marked for a distance of about a mile and a half around the west and south sides of the island. At its northernmost extremity it is finely developed at a height of 105 to 118 feet above high-water mark of spring tides. On the south coast on both sides of Gometra House measurement gave 110 feet as the height of the inner angle. Traced east along this coast, however, it appears to decline somewhat, measurements giving successively the figures 105, 100, and 95 feet at different points within half a mile east of Gometra House. An outlying portion of the platform along the west coast appears to have a distinctly ice-moulded surface. On the north and south shores of Ulva there are some irregular shelves, which might be interpreted as portions of the preglacial marine platform, but, as little reliance can be placed on them, they will not be described here.

The preglacial platform fringes with almost perfect continuity the whole west coast of Mull from Port Burg to Treshnish Point, being everywhere backed by very fine cliffs about 200 feet high. Being, like the modern shore, controlled to a large extent by the relative strength of the gently inclined basalt flows, it varies a good deal in height. Where softer strata overlie a powerful lava bed it may begin at a certain spot quite low (100 feet or so above high-water mark) and rise along the dip slope of the lava bed, until it is perhaps 20 feet higher than when it started on this bed. When, however, it reaches an altitude of 120 or 125 feet it invariably breaks through the strong bed and begins again at a lower level. At Rudh' à Chaoil, where the lavas lie approximately horizontal, a magnificent level platform with cliffs nearly 300 feet high is developed at a height of 120 to 125 feet above high-water mark of spring tides. The platform is here and in other places along this coast nearly a quarter of a mile wide, and it is impossible to confound it with the ledges produced by the irregular weathering of the basalts. The persistence of its general level for the distance of 5 miles, throughout which it is here continuously developed, places its marine origin beyond doubt. Opposite a hollow in the preglacial cliff east of Rudh' à Chaoil the surface of the platform has a distinctly ice-moulded appearance.

The southern shores of Calgary Bay show only some very doubtful remnants of the preglacial beach, but on its northern side the platform resumes the magnificent development exhibited along the coast to the south, and this it maintains round the coast of Mornish to the north as far as the Caliach Point. It shows the same tendency to conform in level to the upper surface of strong beds, but, as before, abandons these beds when they depart too much from its normal level. In one or two places its surface has an appearance of ice-moulding. A measurement of height made about one mile south of the Caliach Point gave 115 feet as approximately the normal level in this vicinity, but the inner angle rises in places to 120 feet and sinks in others to 105 feet. Another estimate at the head of Calgary Bay gave 110 feet as about the normal, while portions of the platform are as low as 95 feet and others rise to 115 feet.

South of Loch na Keal the Mesozoic rocks of Gribun afford no certain traces of the preglacial beach, but at the foot of the magnificent escarpment known as The Wilderness, to the west of Ardmeanach, well-marked remnants can be seen. It is probable that along this coast considerably more of the platform is preserved than appears to view, for the whole is much obscured by scree and landslips descending from the immense cliffs above. As we pass south along the coast from the farm of Balmeanach certain obscure traces are seen at Coireachan Gorma, but the first undoubted remnant occurs at Stac Glas Bun an Uisge just to the north of the river. Half a mile further south, at Rudha nan Goirteanan, it is, however, much finer, being cut in the schistose grits of the Moine Series. The platform is here much obscured by material from the cliffs above, but the section afforded by a geo enables it to be traced beneath the scree almost into its inner angle. Measurements showed the highest portion seen to lie at a height of 98 feet. The inner angle is probably a few feet higher. The cliff is composed of the same schists as the platform, and appears where seen to be somewhat rounded and moulded. The great cliff above from which the scree descends is not the cliff of the raised beach but the escarpment of the Tertiary lavas. The surface of the preglacial platform is ice-moulded. It probably extends continuously from here to Uamh nan Calman. At Rudha na h'Uamha there is a volcanic neck with associated columnar basalts.

A well-marked platform cut in these latter can be seen emerging from beneath the scree. It probably extends south of the point for some distance. Levelling showed its height to be about 110 feet, where it can be seen passing beneath the scree, but its inner angle is probably a little higher, say 115 feet.

In Iona remnants of the preglacial beach are poorly preserved. It possibly never attained any regularity or perfection of development here owing to the nature of the country rock. There seem, however, to be traces of it on the south-east face of Drum Dhùgaill and the hill to the north, and also west of Dùn Cùl Bhuirg, where many of the crags are reduced to a level of 115 to 130 feet, but very irregularly. On Erraid and north of Fidden, on the adjoining coast of the Ross of Mull, there are considerable areas at about the same level, which may be portions of the old platform much modified by glaciation.

V. The Treshnish Isles.

The Treshnish Isles are a small group lying to the west of Mull outside Gometra and Staffa. Only two of the islands, the Bac Mor and Lunga, are of sufficient height to show the preglacial shoreline, but on both of these it is remarkably developed. The Bac Mor, commonly known as the Dutchman's Cap, is a striking object. Visitors from the neighbourhood of Oban who have seen the beautiful terraces of the 25-foot beach surrounding the islands of that district cannot fail to recognize here a similar phenomenon on a much grander scale. From the broad platform of the preglacial beach which forms the rim of the hat, the central eminence rises steeply to a height of 284 feet above O.D. The platform, which forms more than two-thirds of the area of the island, lies almost entirely below the 100-foot contour. The slope of the platform, which is higher at the north end, is more or less controlled by the rock-structure, the slight dip of the lavas (as apparent when viewed from the south-east) being towards the south or south-west in the Bac Mor and towards the north in the Bac Beag. The control is, however, not nearly so marked as might at first sight be imagined, and there is no bed sufficiently strong to lead to the production of the shelf through atmospheric weathering or glacial erosion alone. The shelf, indeed, shifts from one bed to another, and in this manner varies considerably in level.

Owing to the absence of any modern beach deposits and of the zone of *Fucus canaliculatus*, which indicates the high-water mark on most rocky coasts, accurate determinations of level were rendered rather difficult. As a datum it was necessary to take the upper limit of Balanus, a much less reliable index of high water than the seaweed zones. Estimating from this, however, the inner edge of the platform round the south side of the central hill was found to be from 75 or 80 feet to 90 or possibly 95 feet above high-water mark of spring tides. The general level of the more outlying portions of the platform at this south end was 70 to 75 feet, rising to near 80 feet on the Bac Beag.

At the north end of the central hill, with the same difficulty of determining high-water mark, the inner angle was found to be at a height of from 90 to 95 feet. At the extreme north end of the island the platform is on the whole a few feet higher, say 97 feet above high-water mark. At the west side of the central hill there appears to be a higher fragment of platform at 110 feet, but this is rather doubtful.

The platform is everywhere remarkably ice-moulded. No striæ were observed, but from the aspect of the *roches moutonnées* it is clear that the ice came from the N.E. or E.N.E., an observation agreeing with the trend of the striæ in Ulva.

Lunga, the largest of the Treshnish Isles, has a still more extensive platform, which occurs all round the island except for local interruptions in one or two places. The lavas lie nearly horizontal with a very gentle dip to the north. The platform at the north end is controlled by the occurrence of a very massive lava bed some 80 or 100 feet thick. The inner angle at the ruined houses is just 100 feet above high-water mark of spring tides. As the massive bed is followed south along the east side of the island it rises steadily and carries up the platform with it to a height of 110 feet or more. Soon, however, the platform abandons the massive bed and starts again to the south of Cruachan at a lower horizon in the lavas. Here, as in the case of the Bac Mor, it is at a very low level, the inner angle being only 80 or 85 feet above high-water mark of spring tides, and the general level of the platform, which extends for three-quarters of a mile to the southern extremity of the island, only 75 or 80 feet. At the extreme south end it appears to rise again to 85 feet. Along the west side only irregular remnants are preserved.

Along the north, east, and south of the island the platform is even more remarkably ice-moulded than on the Bac Mor, so that there is absolutely no doubt as to its preglacial age. The ice-motion was, as before, from the N.E. or E.N.E., but no striæ were found.

VI. Conclusion.

The continuity of the old cliff and platform along stretches of coast many miles in extent, and the manner in which the latter maintains a uniform level independently of, and often in spite of, the rock-structure, are sufficient proof that we are dealing with an old shore-line. The repeated ice-moulding of the surface, and above all the superposition in some localities of large masses of boulder-clay, show that the feature was in existence before the Great Ice Age. Its development as a rock-platform is quite comparable with that of the preglacial beach of Southern Britain, but a correlation between the two would at present be very unsafe. The main obstacle is of course the want of preservation of deposits in connexion with the platform of the Western Isles. Even in the absence of these it might be possible to correlate if we could be sure that these old shorelines were the only ones of immediately preglacial age in their respective districts. At present, however, we cannot be sure that other platforms of marine erosion do not exist below sea-level. Moreover, in the south of Colonsay and in Oronsay there are vague indications, first pointed out by Mr. Bailey, of a possible plain of marine erosion a little above the present sea-level. The evidence for this second preglacial platform, to which reference has been made above (Section II), cannot, however, at present be regarded as at all satisfactory, and unless its existence is confirmed by evidence in other districts it need not be taken into account theoretically.

In Southern Britain the deposits of the preglacial raised beach are overlain by 'head' or 'rubble-drift', and a conspicuous feature of the preglacial shoreline is the rounding off of the old sea-cliff owing to atmospheric degradation at the time of formation of this head. It is worthy of note that where the preglacial cliff of the Western Isles is best preserved, as in Mull and parts of Colonsay, no such

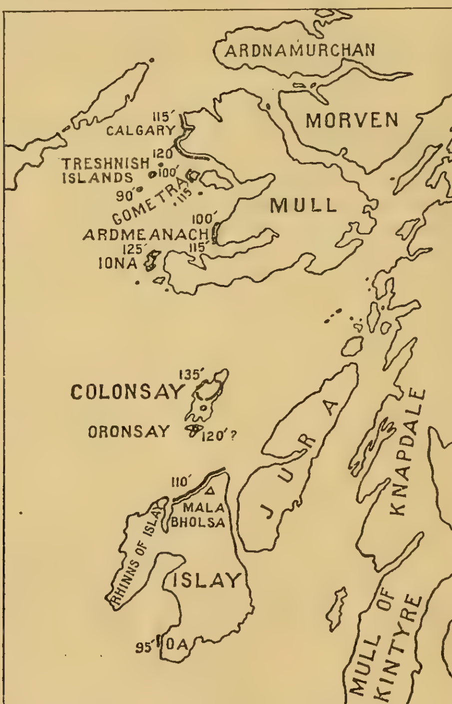


FIG. 4. Sketch-map on the scale 25 miles to the inch, showing the known localities and heights of the preglacial raised beach of the Western Isles of Scotland. The preglacial beach is shown by a black line, and the figures give its observed heights in the different localities.

rounding is observable. Some allowance must no doubt be made for the nature of the rocks of which the cliff is formed, but, taking everything into account, there is a distinct suggestion that the Scottish cliff was never exposed to the same process of degradation as that of the south. It may possibly have been below sea-level, but it is more likely that it was already buried in ice long before the setting in of the severe climatic conditions which caused the formation of the head.

A review of the various measurements quoted above and a consideration of the maximum heights of the platform in the different islands (see Fig. 4) would seem to indicate some deformation of the shoreline. Owing, however, to the possibility of cumulative errors of observation, to the probability that the inner angle did not always bear the same relation to high-water mark, and to the subsequent extensive modification by glaciation, I do not at present wish to lay much stress on this point.

Having up to the present avoided all considerations of a speculative nature, I may perhaps be permitted in conclusion to suggest a working hypothesis. It is well known that the late-glacial 100-foot beach is confined to certain parts of Scotland, being absent in England, Ireland, and the extreme north of Scotland (Caithness) (see Fig. 1). Throughout its area of distribution it maintains, moreover, a fairly uniform level of 100 feet above the sea, and where it disappears it does so abruptly, not dipping gradually below sea-level like the 25-foot beach. Now the (0 to 12-foot) preglacial beach of Southern Britain has not been traced within the area of the 100-foot beach. Well within this area we find, however, the (100 to 135-foot) preglacial beach of the Western Isles. Now, making the admittedly dangerous correlation between the two preglacial beaches, the approximate coincidence of figures suggests that the movement (possibly block-faulting) which brought the 100-foot late glacial beach into its present position was also responsible for the elevation of the preglacial beach in the Western Isles of Scotland.

II.—Notes on British Dinosaurs.[1] Part IV: *Stegosaurus priscus*, sp. nov.

By Baron Francis Nopcsa.

(WITH NINE ILLUSTRATIONS IN THE TEXT.)

SINCE the *Omosaurus* of the Kimeridge Clay may still be regarded as the only well-known European representative of the Stegosauridæ, it seemed advisable, after discussing in previous papers the Ornithopodous *Hypsilophodon* and the Acanthopholidid *Polacanthus*, to examine a representative of this type. I am therefore greatly indebted to Dr. A. S. Woodward for permitting me to do so at the Natural History Museum, and also for putting at my disposal a magnificent hitherto undescribed Stegosaurian discovered by Mr. Alfred Leeds, F.G.S., in the Oxford Clay of Fletton, near Peterborough.

On account of the small elevation of the neural arch of the dorsal vertebræ I propose to name this new Stegosaurian species *Stegosaurus priscus*.

The type-specimen of *St. priscus* in the Natural History Museum bears the register number R. 3167, and is represented by numerous

[1] Part I, *Hypsilophodon*, with a page illustration, appeared in the Geol. Mag., 1905, pp. 203–8; Part II, *Polacanthus*, op. cit., pp. 241–50, with Plate XII and 8 text-figures; Part III, *Streptospondylus*, op. cit., pp. 289–93, Plate XV (all in Decade V, Vol. II, 1905).

bones; a second individual, of which the distal end of the pubis and some dermal plates have been described by von Huene as *Stegosaurus* sp.,[1] is in the Sedgwick Museum at Cambridge.

The type-specimen of *St. priscus* is represented by the following material: 2 anterior cervical vertebræ including the axis, 9 dorsal vertebræ or fragments of such, 15 caudal vertebræ, 1 cervical rib, fragments of chevron bones, 3 left and 1 right dorsal ribs, the right humerus and ulna, the left femur and parts of the corresponding tibia and fibula, carpal bone, astragalus, and calcaneum, fragments of both ilia, parts of both pubic and ischiac bones, parts of the dermal armour.

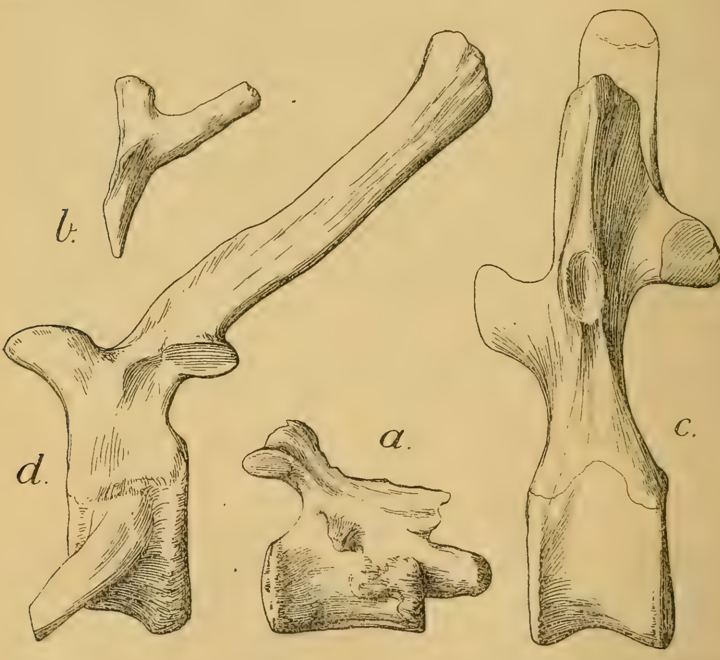


Fig. 1. *a.* Axis of *St. priscus* seen from the right (most of the neural spine wanting). *b.* Anterior cervical rib of same. *c.* Dorsal vertebra of the same. *d.* Middle caudal vertebra of the same.

Vertebræ.—The axis of the Fletton Dinosaur is of special interest, for hitherto no axis of a Stegosaurian has ever been described or figured. It is 12 cm. long; at the posterior end its body is 4·8 cm. wide and 4·5 cm. high. Unfortunately the neural arch is much mutilated, as shown in Fig. 1*a*.

The odontoid projects far forward; the centrum is strongly compressed laterally, but as shown by the irregular split-like section of the neural canal this is to some degree due to post-mortem deformation. This deformation has also caused the basal keel of the centrum to be more

[1] Centralblatt für Mineralogie, Geologie, und Palaeontologie, Stuttgart, 1902.

marked in the fossil than it may have been in the living animal. The anterior and inferior margins of the centrum show strong rugosities. On the posterior margin two hypapophysial knobs are present. The anterior articular surface of the centrum is plane, the posterior moderately concave; both surfaces show a straight superior and equally rounded lateral and inferior border, having thus the shape of a circular disc, of which a segment is missing.

The articular surfaces for the first cervical rib are situated on the anterior superior part of the centrum, and on the middle of the arch immediately above the neuro-central suture. The neural arch is much mutilated, and only one post-zygapophysis is preserved, which is situated comparatively high above the centrum. Its articular surface is not clearly defined, and is directed outward and downward.

With the exception of its being a few millimetres shorter, the second vertebra, of which only the centrum is preserved, has practically the same shape as the axis, the chief differences being the stronger development of the hypapophysial knobs and the evidently more elevated pleurapophysis, for no trace of it can be found in the part preserved. Compared with the cervicals of the new *O. Lennieri*, preserved at the Havre Museum, the description of which will shortly be published elsewhere, there is a great difference in the laterally compressed centra of *St. priscus* and also in the rectangular shape of the neural platform (Hulke), which is sandal-shaped in *O. Lennieri*, being strongly contracted in the middle. No great difference between the cervicals of our *Stegosaurus* and the American *Stegosaurus* is apparent.

It does not seem improbable that the left triradiate cervical rib, represented in Fig. 1*b*, belonged to this or to the following vertebra, for the distance of the capitulum and tuberculum would correspond to the proportions we should expect to find in these vertebræ if they were complete.

Besides two processes for the capitulum and tuberculum and the comparatively short and flattened body of the rib, this bone shows on the exterior part a well-marked excrescence, which is represented in most Dinosaurs only by a feeble ridge, but is well developed, though with altered direction, on the cervical rib figured by Marsh as a rib of *Apatosaurus*. In *Stegosaurus* this excrescence is pointed outward and forward, and it may perhaps be best compared with the dilatation of the cervical ribs in some Lacertilia. It may have served for the purpose of combining a limited amount of flexibility with strength in this region of the body. A quite similar, though more ridge-like excrescence is also met with on the thoracic ribs of *Stegosaurus*, and produces there, together with a similar posterior ridge, the oblique T-shaped cross-section that has been specially noticed in *Stegosaurus*, but seems, as far as I am aware, to be present also in other members of the Orthopodous order.[1] Its origin may therefore have to be explained otherwise than through the weight of the dermal armour.

The dorsal vertebræ of *St. priscus* (Fig. 1*c*) approximate in general

[1] I would suggest that the Dinosaurians represent a distinct super-order, which may be divided into two orders, Saurischia (Seeley) and Orthopoda.

to the type of *St. ungulatus* and *O. armatus*. Several differences, however, may be noted as distinguishing this species quite clearly from either of the others.

In *St. ungulatus* the point from which the diapophysis arises is much higher above the bottom of the neural canal than in our specimen; in *O. armatus* this point is very much lower. Corresponding with this difference the elevation of the prezygapophysis in our specimen is also intermediate between that in the two other animals; while *O. Lennieri* shows much the same stage of specialization as *O. armatus*. The direction of the diapophyses is also different in the different animals, for they are directed more outward than upward in *O. armatus*, more upward than outward in *St. ungulatus*, and equally outward

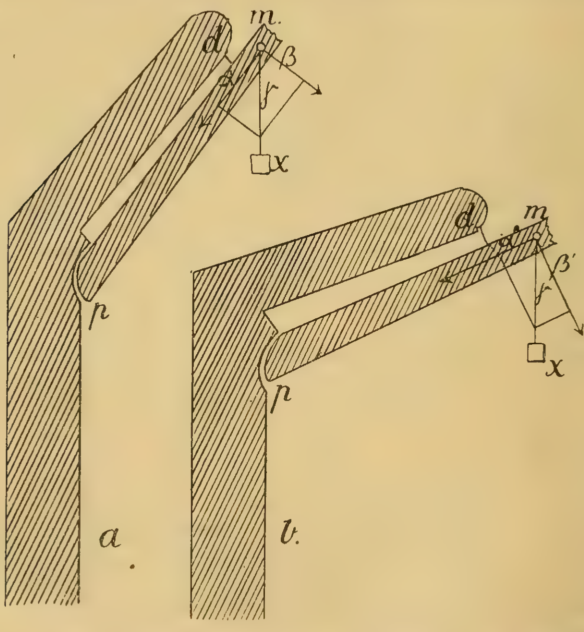


FIG. 2. Diagram illustrating the difference of strain on the diapophysis as correlated with the elevation of latter. *a*. Stegosaurian type. *b*. Omosaurian type. p = parapophysis; d = diapophysis; x = weight of dermal armour acting on the rib by m; γ = amount of vertical pressure; α (α') = pressure on parapophysis; β (β') = strain on diapophysis.

and upward in *St. priscus*, the angle that they form with the neural spine being in the latter just about 45 degrees. Comparing these data with *Scelidosaurus*, we remark that the elevation of the diapophyses steadily increases as these animals specialize. Since the bones of these animals are not pneumatic, and since a similar elevation is not present in the mammalia, though in these the development of lungs is much more important than in reptiles, I do not believe this elevation had anything to do with the development of the lungs as generally accepted, but I think it is rather due to the increasing weight of the double row of dorsal plates. It is evident that a rib fixed to the parapophysis and diapophysis in the Stegosaurian way was much more fitted for supporting weight than one in which the two points of attachment were nearer to each other and more on a horizontal plane, with the rib directed nearly at right angles to the vertebral column.

To illustrate this the diagrams Fig. 2*a* and 2*b* were drawn according to the evidence afforded by *O. armatus* and *St. ungulatus*. By breaking up in these figures the vertical pressure of the dermal armour on the rib γ into its components a (a') and β (β'), it becomes clear that in *St. ungulatus* (Fig. 2*a*) the strain (β) on the diapophysis (d) is by *m* just about half as strong as in *O. armatus* (Fig. 2*b*, β') while the pressure a (a') on the parapophysis (p) is augmented, for $a' = \frac{a'}{2}$ and β' is larger than β. In animals where the dermal armour becomes supported by the vertebral column and not only by the rib, as in crocodiles, tortoises, Ancylosauridæ, and some others, such an elevation of the diapophysis need not be developed.

Even the strong downward curve of the rib beyond its culminating point, reducing as it does the transverse diameter of the body-cavity, is probably more due to the pressure of the dermal armour than to anything else, for it is evident that with a rib curved strongly downward the dilatation of the body-cavity, as necessary for breathing, can be easily brought about by contraction of the musc. levator costarum without shifting the weight of the dermal armour, while this would be impossible if the distal ends of the long ribs were not directed downward but outward.

Since *Stegosaurus* was probably a cold-blooded animal, the increase of body-surface and greater loss of heat as resulting from the lateral compression of the body would, of course, in this animal not be of so great importance as in a warm-blooded animal, where there is a minimum of body-surface united with greatest capacity for the respiratory organs; thus a more rounded body-section is needed.

Two other quite marked features of the dorsal vertebræ of *St. priscus*, in which this animal makes a close approach to *St. ungulatus*, are the lateral compression of the neural canal and the absence of cavities on the sides of the centrum. The shape of the transverse and longitudinal sections of the plano-concave centra seem, however, otherwise to be the same in both Omosaurs and Stegosaurs.

A good view of a middle dorsal vertebra is given in Fig. 1*c*, which is based principally on one bone, but has both zygapophyses restored on evidence afforded by another specimen.

The sacral vertebræ are all wanting in *St. priscus*, but the proximal middle and distal caudals are each represented by numerous pieces.

The anterior caudals (Figs. 3*a*, *b*) are of the same type as in *Omosaurus*, the chief difference being only that the tubercle on the superior border of the dilatated costoid is somewhat less developed in the former than in the latter. On these strongly abbreviated vertebræ no chevron bones seem to have articulated. The proximal caudals of *St. priscus* are easily distinguished from *St. ungulatus* by the weaker development of the neural spine and the costoids.

The middle caudal vertebræ (Fig. 1*d*) of *St. priscus* have the neural spine more elevated than in *O. armatus*, but not cleft at the top as in *St. ungulatus*. The section of the rod-like neurapophysis is triangular at the base, but oval and somewhat laterally compressed at the summit. The post-zygapophyses are not much elevated above the neural canal, they are directed both straight downward and outward. The pre-zygapophyses are correspondingly directed upward and outward. The

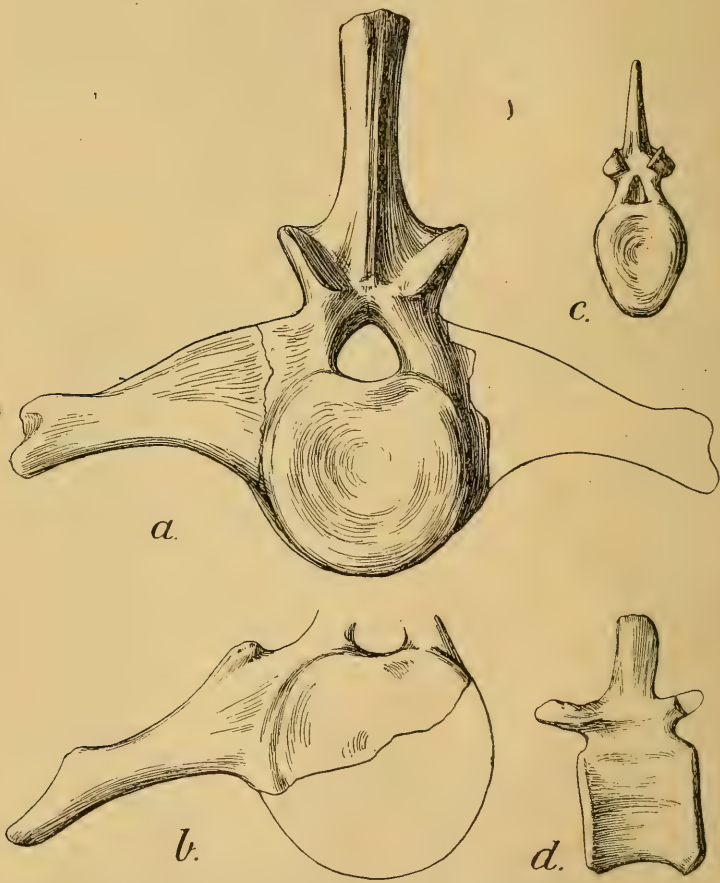


Fig. 3. *a*. First (?) caudal of *St. priscus*. *b*. Proximal caudal of the same. *c*. Anterior view of distal caudal. *d*. Lateral view of the same.

moderately short centra of these vertebræ are concave at both ends, more so posteriorly than in front; the sides are flat, the bottom keeled, the articular surfaces for the chevron bones large, equally developed at both ends, and nearly touching each other on the basal ridge. They are not easily distinguishable from the rugosities that occur round the margin of the articular ends of the centra. The costoids in the middle of the tail are rod-like elements, decreasing rapidly in size backwards. There is a great resemblance to the middle caudal vertebræ in *St. ungulatus*.

The distal caudals in *St. priscus*, as shown in Figs. 3*c*, *d*, are still more elongate than the middle ones. The centrum is laterally compressed, as Fig. 3*c* shows, and exhibits a pentagonal section, with the point of the pentagon turned downwards. The articular surface for the chevron bone on these vertebræ is only developed at the posterior end. The concavity of the articular surface is also more marked at this end than at the other. The neural arch in these vertebræ, as in all the anterior ones, covers nearly the whole of the neural canal; the elongate rod-like prezygapophyses are comparatively feeble, their articular facets are directed as in the middle dorsals. The narrow neural spine (Fig. 3*d*) rises in a remarkable manner straight upwards; it is blade-like, tapering towards its summit, and, like the rest of this vertebra, it is characterized by the complete want of rugosities, thus indicating clearly that on this bone no great mass of firmly adhering tissue was present during life. This latter observation will prove to be of the utmost importance when we discuss the dermal armour of *St. priscus*.

The distal caudal in *St. priscus* differs from that of *St. ungulatus* and *Diracodon* by the feeble development of the neural spine, and still more by the development of elongate post-zygapophyses, for these are quite short and nearly sessile on the blade of the neural spine in *St. ungulatus*, *Diracodon*, and many other Dinosaurs, though not in *Polacanthus*. The development of the neural spine and the post-zygapophyses in *St. priscus* are features so strange for a posterior caudal that if the shape of the centra did not prove beyond all doubt the contrary, one might hesitate to refer this vertebra to an *Omosaurus*. The biconcave nature of all the caudals of our *Stegosaurus*, and the neural spines overlapping each other, do not imply great flexibility of this organ.

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

III.—Sedgwick Museum Notes.

New Crustacea from the Lower Greensand of the Isle of Wight.

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

(PLATE VII.)

Amongst the large series of specimens of *Meyeria* recently obtained by the Sedgwick Museum, Cambridge, from the Lower Greensand of Atherfield, Isle of Wight, two new and strange forms, obviously referable to another genus, were detected by me in looking over the material. Their interest consists not only in belonging to new species but in representing the genus *Thenops*, of which the best known and only British species, so far described, is *Th. scyllariformis*, Bell, from the London Clay. There is one imperfect specimen in the British Museum from the Speeton Clay attributed (with a query) to *Thenops*, but no other British representative from the Cretaceous appears to have been found.

THENOPS CARTERI, sp. nov. (Pl. VII, Figs. 2, 2*a*.)

Description. Carapace elongated, narrowing anteriorly, divided at about half its length by cervical groove; median dorsal portion of carapace flattened, especially in thorax, with lateral portions bent down steeply on each side along tuberculated longitudinal lateral carinæ.

Cervical groove deep, strongly marked, divisible into (1) a short middle transverse portion slightly arched forwards and about one-fourth the width of the carapace at this level, and (2) a pair of lateral portions bent sharply forwards on each side and running out so as to meet the lateral carinæ at about 45°, outside which they bend down almost at right angles to inferior edge of carapace but turn forwards close to margin to meet it at an acute angle.

Posterior end of carapace concave in outline, and furnished with a narrow rounded ring with pitted surface marked off by a strong smooth furrow.

Cephalic portion of carapace with upper surface very gently convex, and defined on each side by slightly curved, fine lateral carinæ diverging backwards from rostral teeth to cervical groove, and marked by row of small sharply pointed tubercles increasing in size posteriorly.

Anterior end of cephalic portion abruptly truncate, furnished with median pair of short triangular rostral teeth somewhat flattened with their faces inclined inwards and their points about one-third the anterior width of the carapace apart. Median notch between rostral teeth rounded. Anterior edge of carapace outside rostral teeth simple, nearly straight, not excavated nor dentate, meeting lateral edges nearly at right angles. Median portion of cephalic region forming a slightly elevated sub-lanceolate pre-gastric area, ill-defined at the sides and behind where at about half the length of the cephalon it touches two sub-parallel, gently curved longitudinal rows of 6–7 spinose tubercles, bounding laterally the narrow, elongated, somewhat flattened gastric region reaching back to the cervical groove and having a width equal to about one-fifth that of the base of the cephalon.

A pair of low indefinite longitudinal ridges run back from the bases of the rostral teeth with a slight divergence to the level of the anterior end of the gastric region, where they end in somewhat marked depressions, prolonged outwards as weak grooves curving back to the lateral carinæ and marking off indistinctly on each side of the gastric region a sub-triangular area in front of the cervical groove. Outside the lateral carinæ of the cephalon the carapace is bent down, very slightly at the anterior end, but with increasing steepness posteriorly. Inferior edge of carapace thickened and armed with large closely set spinose tubercles.

Thoracic portion of carapace with upper part horizontally flattened, but medially somewhat elevated into cardiac region and bearing a longitudinal carina of large pointed tubercles. Cardiac region with slight independent swelling, about two-thirds the length of thorax and one-third its width, sub-lanceolate in shape and marked out on each side by weak furrows gently curved, but not defined behind. On each side of cardiac region thorax is flattened and horizontally extended to the strong lateral carinæ, which are gently arched outwards and formed by a row of large sharply pointed tubercles directed forwards and increasing in size from the posterior margin of the carapace to the cervical groove. Outside these carinæ the sides of the thorax are bent down almost at right angles.

Surface of carapace ornamented with small, widely separated, sharply pointed tubercles. On the cephalon the tubercles are not numerous, and are irregularly distributed, or obscurely in longitudinal series; on the thorax the tubercles are larger and arranged on the upper flattened portion at equal distances apart in fairly distinct longitudinal lines parallel to the lateral carinæ, but on the steeply inclined sides they are less regularly placed and are more closely aggregated immediately behind the cervical groove.

The large tubercles of the median and lateral carinæ are conical and sharp with the points directed forwards.

Second antennæ composed of large flattened and ridged joints (only part of one joint on the left side is preserved).

Abdomen gently convex, broad; surface of terga flat, but bearing a thin elevated longitudinal median carina; lateral edges of terga slightly thickened; surface of shell densely but finely pitted. Epimeres becoming successively longer and sub-falcate; epimere of second segment sub-quadrate in shape, wider than long, with straight lower edge and swollen band on anterior margin, ending above in articulating peg to fit into socket of preceding segment. Epimeres of third and fourth segments longer than wide, sub-falcate, anterior and lower margins forming a continuous curve, and posterior edge serrated; upper anterior corner swollen and cut off by oblique furrow and projecting as articulating peg; surface of shell finely pitted, but less densely than rings. Peræopods compressed, slender, with surface smooth and sparsely pitted.

Dimensions.

	mm.
Length of carapace along median line to rostral notch . .	33·5
Length of thorax along median line	17·0
Width of thorax between lateral carinæ at posterior end . .	17·0
Width of thorax at point of section of lateral carinæ by cervical groove	13·5
Width of head at anterior end between outer lateral angles .	16·0
Width of abdomen	16·0

Holotype. Carapace with portion of one of the right peræopods, one joint of left second antennæ, and with four segments of abdomen attached. From the Lower Greensand, Atherfield, Isle of Wight.

Affinities. This species is undoubtedly allied to the London Clay form *Thenops scyllariformis*, Bell.[1] The peculiar flattening of the upper part of the carapace, the sharply bent down lateral portions, the lateral and median carinæ, the general development of the gastric and other regions, the pair of rostral teeth, and the simple straight anterior edge of the carapace are features in common. There are, however, certain obvious differences which a comparison with the large series of splendidly preserved examples of *Th. scyllariformis* from Portsmouth

[1] Bell, Mon. Foss. Malac. Crust. (Palæont. Soc.), 1857, p. 33, pl. vii, figs. 1–8.

in the Sedgwick Museum clearly brings out. In the first place the thorax of the London Clay form has its sides nearly parallel; the lateral carinæ are less marked; the cephalic part of the carapace is shorter and broader; the anterior lateral angles are produced forwards into stout spinose processes; the cervical groove is not divisible into three parts, but forms a continuous gentle curve meeting the lateral carinæ less acutely; the hepatic depressions are deeper and larger; the gastric region is lyre-shaped, and there is a prominent large median tubercle just in front of it; the abdomen is less convex and the surface of the segments is much more coarsely and closely pitted, and the median ridge rises into a stout tubercle; and, finally, the tubercles on the general surface of the carapace are low and rounded or transverse.

Our new species may be appropriately dedicated to the late Dr. Carter.

The Lower Senonian species known as *Podocrates dülmensis* (Becks MS.) [1] is closely related in many respects to *Th. Carteri*, but differs by having the orbits excavated and the anterior margin of the carapace toothed; the tubercles around and in front of the gastric region are differently disposed; the lateral carinæ of the thorax are not regularly arched outwards; the cervical groove is more gently and regularly curved; there are fine oblique furrows on the steep sides of the carapace; the tubercles on the carinæ and carapace generally are rounded and not sharply pointed; the abdomen has a median tubercle and a pair of lateral ones instead of a longitudinal keel, and the rings are not pitted.

In spite of Schlüter's [2] contention that *Podocrates*, Becks MS., 1850,[3] is synonymous with *Thenops*, Bell, 1857 (op. cit.), there seems reason to doubt it, on account of the orbits in the former being excavated and the anterior margin toothed, whereas in *Thenops* the anterior edge of the carapace on each side of the rostral teeth is straight, simple, and not indented or toothed. For this reason it appears desirable to place our new species from Atherfield in the genus *Thenops*, which has *Th. scyllariformis* as its type.

Thenops tuberculatus, sp. nov. (Pl. VII, Figs. 1, 1*a*, 1*b*.)

Description. Carapace elongated, narrowing anteriorly, divided transversely into two unequal parts by cervical groove; median dorsal portion of carapace flattened; lateral portions sharply bent down on each side along obscure lateral carinæ curving down somewhat posteriorly.

Cervical groove strong, smooth, consisting of three parts—(1) a short transverse median portion about one-fourth the width of the carapace at this level, and (2) a pair of lateral portions bending forward sharply and running in a slightly sigmoidal course to meet the lateral carinæ at about 45°, outside which they bend down and cross the sides at right angles.

Posterior end of carapace strongly concave in outline, with lateral

[1] Schlüter, Zeitschr. deut. geol. Gesell., Bd. xiv, p. 713, t. xii, figs. 1–3, 1862.
[2] Ibid., p. 710; id. op. cit., Bd. li, pp. 409–30, 1899.
[3] Geinitz, *Die Quadersandstein*, 1850, t. ii, fig. 6 (no description).

angles somewhat produced backwards and pointed, and with a narrow rounded tuberculate ring marked off by a smooth furrow.

Cephalic portion of carapace gently convex between lateral carinæ, which converge anteriorly and end just outside base of rostral teeth. Lateral carinæ marked by specially large tubercles posteriorly, decreasing in size anteriorly. Median portion of cephalon gently swollen into obscurely defined sub-lanceolate pre-gastric area passing back imperceptibly into gastric region, which is marked in front by a pair of specially large tubercles situated rather behind the middle of the cephalon. Gastric region narrow, somewhat depressed, oblong defined on each side by irregular row of rather large tubercles running back to cervical furrow. A weak depression lies on each side of the anterior pair of gastric tubercles and is prolonged outwards into a weak furrow curving slightly back to the point where the cervical furrow crosses the lateral carinæ. Rostral teeth triangular (imperfectly preserved), separated by sharply rounded notch, with their faces flattened and inclined inwards. A narrow indistinct post-rostral ridge, marked by a few large tubercles, decreasing in size posteriorly, runs back from the base of each rostral tooth to the depressions (hepatic) on each side of the gastric region. Anterior edge of lateral portions of carapace not preserved. Sides of cephalon posteriorly bent down at right angles to upper surface along lateral carinæ.

Surface of cephalon ornamented with sharply pointed, conical tubercles smaller and fewer than on thorax and less closely placed, but tending to be arranged in longitudinal lines especially towards the lateral carinæ.

Thorax horizontally extended and flattened dorsally between lateral carinæ, with median portion somewhat elevated and provided with median longitudinal keel bearing a row of specially large, sharply conical tubercles. Lateral portions of thorax bent down at right angles to upper portion without the formation of definite lateral carinæ posteriorly, but anteriorly towards cervical groove the angular line of bending is marked by definite line of large conical tubercles. Sides of thorax decrease in height posteriorly owing to lateral line of bending curving down behind. Cardiac region gently elevated and defined by pair of weak smooth furrows, gently curved outwards and reaching two-thirds the length of the thorax; width of cardiac region across middle about one-third that of thorax. Anterior margins of thorax swollen slightly on each side behind and along cervical groove into a low rounded ridge, widening a little laterally to the lateral carinæ against which it ends.

Surface of thorax covered with large, sharply pointed, conical tubercles, mostly of equal size and closely placed, but not in any determinable order; on the sides these bases are nearly or quite contiguous. Both the large tubercles on the carinæ and those on the general surface of the carapace have their sharp points slightly arched and directed forwards.

Abdomen strongly arched from side to side (five segments preserved); tergum with general surface flat, and with a thin median longitudinal keel; shell covered with small equal-sized numerous pits. Inferior lateral edges of terga somewhat thickened. Epimeres of second to fifth segments sub-triangular to sub-falcate, with anterior and inferior margins forming a continuous curve and posterior margin dentate. Small triangular area cut off by short furrow from anterior upper corner and swollen into peg for articulation.

Peræopods slender, laterally compressed, with smooth surface sparsely dotted with pits.

Dimensions.	mm.
Length of carapace along median line to rostral notch . .	29·0
Length of carapace along median line to level of posterior lateral angles	33·5
Length of thorax along median line	14·0
Width of thorax posteriorly between lateral carinæ . . .	18·0
Width of carapace at point of section of lateral carinæ by cervical groove	13·0
Distance between outer edges of bases of rostral teeth . .	6·5
Width of abdomen	14·5

Holotype. Carapace with five segments of abdomen attached and portions of three peræopods on right side. From the Lower Greensand, Atherfield, Isle of Wight.

Affinities. This species differs from *Th. Carteri* in the more elongated carapace, the smaller development of the lateral keels and their downward curvature posteriorly, the much closer and coarser tuberculation of the surface, the different kind of demarcation of the gastric region, the stronger ridges running back from the bases of the rostral teeth, and in the more convex abdomen. But the most striking differences amongst those above-mentioned are the general shape and tuberculation.

With *Th. scyllariformis* it agrees more closely than does *Th. Carteri* in the development of the post-rostral ridges and in the smaller prominence of the lateral carinæ. But otherwise it has fewer points of resemblance. With *P. dülmensis* the development of the large gastric tubercles is a feature in common, but it is less closely allied to this Senonian species in general characters than is *Th. Carteri*.

From the possession of a coarsely tuberculate surface it may be approximately designated by the specific name *tuberculatus*.

EXPLANATION OF PLATE VII.

FIG. 1. *Thenops tuberculatus*, sp. nov. $\times\frac{3}{2}$. Viewed from above.
,, 1*a*. Ditto. $\times\frac{3}{2}$. Viewed from right side.
,, 1*b*. Ditto. $\times\frac{3}{2}$. Viewed from left side.
,, 2. *Thenops Carteri*, sp. nov. $\times\frac{3}{2}$. Viewed from above.
,, 2*a*. Ditto. $\times\frac{3}{2}$. Viewed from right side.

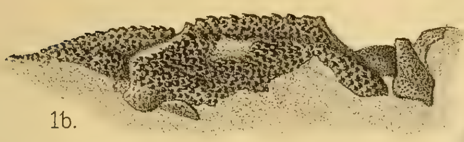
(Both specimens are from the Lower Greensand, Atherfield, Isle of Wight.)

IV.—On the Formation of a Laterite from a practically Quartz-free Diabase.

By Professor J. B. Harrison, C.M.G., M.A., F.G.S., F.I.C.

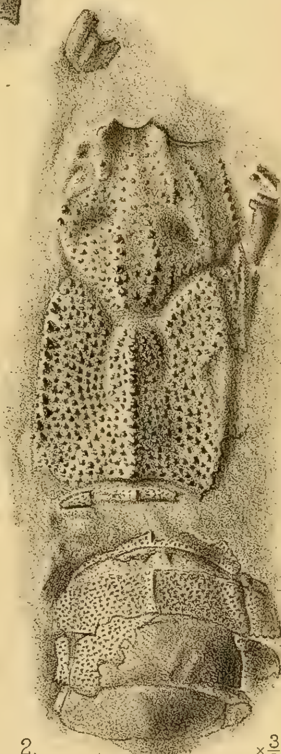
After I had forwarded the paper on "The Residual Earths of British Guiana commonly termed 'Laterite'", published on pp. 439–52, 488–95, and 553–62 of the Geological Magazine for October, November, and December, 1910, I visited the neighbourhood of Christianburgh and Akyma on the Demerara River in British Guiana and examined a small long-deserted quarry in a very fine-grained

1a

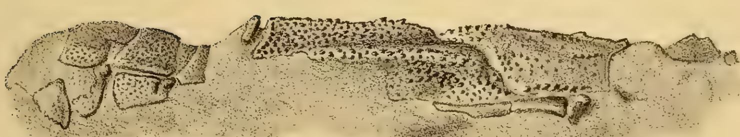


1b.

1. ×$\frac{3}{2}$



2. ×$\frac{3}{2}$



2a

A. H. Searle del. et lith. West, Newman imp.

New Species of Thenops.

diabase intrusive in hornblende-granitite-gneiss near the latter place. I obtained from the lateritic earth lying on the mass of unaltered diabase a boulder of that rock in which the central parts were ideally fresh, whilst the outer parts were decomposed into laterite. I separated these parts with great care into an outer red one, apparently an ordinary ferruginous laterite, and an inner one, buff-coloured with whitish spots in it, which was in actual contact with the unaltered rock. When I obtained the boulder these crusts were quite soft, but after a few days' exposure to the air they hardened considerably.

The diabase of the boulder and its crusts of laterite were analysed by Mr. Reid and myself with the following results:—

	Diabase.	Laterite.	
		Inner crust.	Outer crust.
Quartz	·03	9·38	7·73
Combined Silica	51·06	7·56	4·80
Aluminium Oxide	15·70	34·11	40·33
Iron Peroxide	1·68	20·88	18·28
Iron Protoxide	8·57	3·75	3·84
Magnesium Oxide	7·74	·94	·27
Calcium Oxide	9·11	·84	·10
Sodium Oxide	2·38	·65	·54
Potassium Oxide	1·55	·23	·24
Water (combined)	·35	17·96	19·90
Titanium Oxide	1·70	4·09	4·32
Phosphoric Anhydride	minute trace	trace	trace
Manganese Oxide	·41	*nil*	*nil*
	100·28	100·39	100·35

The chemical composition of the diabase indicated that it should not contain quartz, but as I was desirous of ascertaining directly whether or not the rock contained any quartz I treated some of it in a very finely divided state by Laufer's method (fusion with microcosmic salt). I found by this method that the proportion of silica present in the form of quartz was practically negligible—·03 of 1 per cent. The diabase is therefore practically quartz-free.

The mineralogical compositions of the diabase and of its concentric lateritic crusts may be shown as follows:—

	Diabase.	Laterite.	
		Inner crust.	Outer crust.
Quartz	·03	9·4	7·7
Orthoclase	9·2	1·4	1·4
Plagioclase	47·6	9·7	5·1
Pyroxene	33·8		
Olivine, Serpentine, and Talc	4·1	2·2	·5
Magnetite	2·4	·1	*nil*
Ilmenite	3·2	7·8	8·2
Hæmatite		12·3	17·7
Limonite		9·2	
*Bauxite		47·8	58·9
	100·33	99·9	99·5
*{Diaspore			2·5
*{Gibbsite		47·8	56·4
*Alumina in Bauxite		31·3	39·0

These represent the passage of a normal, practically quartz-free, diabase into a laterite of aluminium hydrate and iron ores, both residuary and secondary, from the ferromagnesian minerals, with some quartz, but without any kaolin. The finely divided quartz was separated from the laterite by long-continued boiling with sulphuric acid, and also by solution of the laterite in dilute hydrochloric and hydrofluoric acids. The residues were examined microscopically in both cases, and proved to consist only of quartz.

The analyses when calculated to a titanium oxide constant basis throw somewhat interesting light on the changes which have taken place during the conversion of the diabase into laterite. The results are shown in the following :—

	DIABASE.	LATERITE.	
		Inner crust.	Outer crust.
Quartz	·03	3·90	3·04
Combined Silica . . .	51·06	3·14	1·89
Aluminium Oxide . .	15·70	14·16	15·87
Iron Peroxide	1·68	8·68	7·59
Iron Protoxide	8·57	1·56	1·51
Magnesium Oxide . .	7·74	·39	·10
Calcium Oxide	9·11	·35	·04
Sodium Oxide	2·38	·27	·21
Potassium Oxide . .	1·55	·09	·09
Water (combined) . .	·35	7·45	7·83
Titanium Oxide . . .	1·70	1·70	1·70
Phosphoric Anhydride .	minute trace	trace	trace
Manganese Oxide . .	·41	*nil*	*nil*
	100·28	41·69	39·87

The proximate mineralogical compositions calculated on the same basis fairly well illustrate the changes in the constituent minerals of the diabase during its conversion into laterite, and are as follows :—

	DIABASE.	LATERITE.	
		Inner crust.	Outer crust.
Quartz	·03	3·9	3·0
Orthoclase	9·2	·6	·6
Plagioclase	47·6	4	2·0
Pyroxene	33·8	*nil*	*nil*
Olivine, Serpentine, and Talc .	4·1	·9	·2
Magnetite	2·4	·1	*nil*
Ilmenite.	3·2	3·2	3·2
Hæmatite		5·1	7·0
Limonite		3·8	
*Bauxite		19·8	23·2
	100·33	41·4	39·2
*{Diaspore			1·0
*{Gibbsite		19·9	22·2
*Alumina in Bauxite . . .		12·9	15·3

The chemical compositions of the diabase and of the outer crust or laterite derived from it when calculated on a titanium oxide constant basis show changes in the following constituents :—

	Gain.	Loss on each Constituent. Amount.	Per Cent.
Quartz	3·01		
Combined Silica		49·17	96·3
Aluminium Oxide	·17		
Iron Peroxide	5·91		
Iron Protoxide		7·06	81·2
Magnesium Oxide		7·64	98·7
Calcium Oxide		9·07	99·5
Sodium Oxide		2·17	91·2
Potassium Oxide		1·46	94·2
Water	7·48		
Manganese Oxide		·41	100

The loss on the total silica is not as high as that shown on the combined silica, as part of the latter has been changed to quartz, the loss on the total silica being 46·16 parts out of 51·09, equivalent to 90·3 per cent. of that substance. Similarly, the loss on the ferrous iron is to some extent set off by a gain in ferric iron, the actual loss of the oxides of iron being 1·74 parts out of 10·29, or 16·9 per cent. The loss of all constituents of the original diabase amounts to 68·2 per cent., and this loss is accompanied by a gain of 7·40 per cent. of water and of ·59 of 1 per cent. of oxygen, so that the decomposition of 100 parts of diabase has resulted in the formation of 39·9 parts of a bauxitic or aluminous laterite.

The position and mode of the exposure of the diabase, a small boss intrusive in a coarse-textured hornblende-granitite-gneiss, indicates that the lateritization is of comparatively recent origin; and it is noticeable that the action is simple, consisting only of such changes as could be produced by the long-continued action of percolating water. The action has taken place above the water-table, and the removal of combined silica from the bases present has been very complete; as far as analytical determinations show, none of it having been retained in combination as kaolin. The outer crust differs from the inner one by its lesser contents of the iron oxides and their lower state of hydration, and to a slight extent by the lower hydration of the aluminium hydrate. If by continued action of water containing readily oxidizable organic matters the iron oxide, other than that present in ilmenite, of the outer crust were removed, a laterite containing over 70 per cent. of aluminium hydrate would result.

V.—Notes on some Upper Devonian Arthrodira from Ohio, U.S.A., in the British Museum (Natural History).

By L. Hussakof, Ph.D., Associate Curator of Fossil Fishes in the American Museum of Natural History.

(PLATE VIII AND THREE TEXT-FIGURES.)

SOME years ago the British Museum acquired from Dr. William Clark a collection of the remarkable Arthrodira found by him in the Upper Devonian shales of Ohio. In this material there are several specimens which were described as new before being brought to Europe, but concerning which there has been more or less doubt among students of the Arthrodira. Hitherto, however, it has been quite impossible to dispel this doubt since the material necessary to a comparative study of the forms in question is to be found only in America. Last year I enjoyed the privilege of going over this material in the British Museum, thanks to the courtesies extended to me by Dr. Arthur Smith Woodward, F.R.S., the Keeper of Geology, and as I had just come from a study of the American forms I was in a position to resolve these doubtful cases. The results of this study are presented in the following pages.

1. The so-called genus Brontichthys.

The name *Brontichthys* was proposed by Claypole in 1894[1] for a large imperfectly preserved mandible having considerable resemblance to that of *Titanichthys*. The type species he named *Brontichthys Clarki*, in honour of the collector, Dr. William Clark. Clark himself subsequently applied the name *Brontichthys*, in manuscript, to a pair of small mandibles which he had found associated with some other remains in a small concretion. Plaster casts of this specimen have found their way into most of the larger museums, and the original itself is in the British Museum (P. 9332).

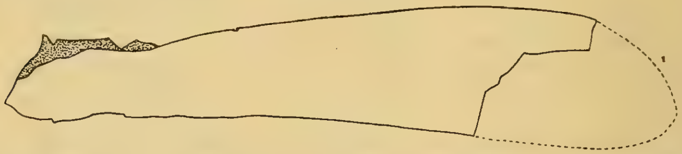


Fig. 1. Mandible of *Titanichthys* sp. Type of *Brontichthys Clarki*, Claypole. × 1/7. Brit. Mus., P. 9298. Cleveland Shale (Upper Devonian): Ohio.

It is obvious that the validity of the genus *Brontichthys* depends upon the type which was described by Claypole, and only secondarily upon the specimen named by Clark. The former, as stated above, is a large, imperfect mandible (British Museum, P. 9298). A figure of it is given above (Fig. 1). On careful examination it is seen to be a mandible of *Titanichthys*, rather crushed and defective in the anterior extremity—which fact misled Claypole, who regarded it as representing a new genus. It also lacks the posterior extremity.

As to Clark's specimen (Pl. VIII, Fig. 2): this consists of a small block of shale containing a pair of small mandibles, two crushing plates apparently of the upper jaw and not well preserved, and one or two fragments. On close examination the mandibles are seen to pertain to a young individual of *Mylostoma variabile*, Newberry. At the time Clark applied the name *Brontichthys* to them, only a few mandibles of *Mylostoma* were known, namely, those figured by Newberry in his *Paleozoic Fishes of North America*; and these were all larger and heavier than Clark's specimen, so that the latter might then have been looked upon as of a different genus. At the present day, however, several small mandibles of *Mylostoma* are available with which Clark's specimen may be compared.

[1] "On a new Placoderm, *Brontichthys Clarki*, from the Cleveland Shale": *Amer. Geologist*, vol. xiv, pp. 379–80, pl. xii. "On a new gigantic Placoderm from Ohio": Third Ann. Rep. Ohio State Acad. Sci., 1895, pp. 8–9.

They agree well, for instance, with the pair of mandibles figured by Dean[1] in the specimen showing the associated head and body plates (American Museum, No. 7526); they are somewhat smaller than the latter. They may also be compared with a juvenile *Mylostoma* mandible in the American Museum (No. 3588). Indeed, there can be no doubt that the specimen which Clark referred to Claypole's genus *Brontichthys* belongs to *Mylostoma*.

From all this it follows that *Brontichthys* is not a valid genus but merely a synonym of *Titanichthys*.

2. Titanichthys rectus, Claypole.

1893. *Titanichthys rectus*, Claypole, Geol. Surv. Ohio, vol. vii, p. 609, pl. xlii, fig. 5.

This species was figured and named, but not sufficiently described. It is, however, a good species. The type is a mandible, 23 inches long (Fig. 3), in the collection of the British Museum (P. 9328). It may be briefly described as follows: Mandible as large as that of *Titanichthys Clarki*, but almost straight fore and aft. Anterior functional portion relatively smaller than the corresponding region in other species of the genus, and not drawn out into an elongate spatulate process, but gradually decreasing in depth to the extremity.

Fig. 3. *Titanichthys rectus*, Claypole. Mandible in inner aspect. × $\frac{1}{6}$. Type. Brit. Mus., P. 9328. Cleveland Shale (Upper Devonian): Ohio.

The species of *Titanichthys* at present recognizable are four in number—

T. Agassizi, Newberry, Trans. N.Y. Acad. Sci., vol. v, p. 27, 1885.
T. Clarki, Newberry, ibid., vol. vi, p. 164, 1887.
T. attenuatus, Claypole, Rep. Geol. Surv. Ohio, vol. vii, p. 612, pl. xlii, figs. 1, 2, 1893.
T. rectus, Claypole, ibid., p. 609, pl. xlii, fig. 5, 1893.

3. Selenosteus brevis (Claypole). (Pl. VIII, Fig. 4.)

1896. *Titanichthys brevis*, Claypole, Amer. Geologist, vol. xvii, p. 166, pl. x.
1910. *Selenosteus Kepleri*, Dean, Mem. N.Y. Acad. Sci., vol. ii, p. 94, pls.

One of the two cotypes of *T. brevis*, Claypole, has been identified by the writer in the British Museum Collection (P. 9330). It consists of a small slab (Pl. VIII, Fig. 4), 23 by 25 cm., with its counterpart and several fragments which apparently formed part of the original concretion. It exhibits both mandibles (*Mnd.*), the median occipital (*MO.*), and a fragment from the lateral margin of the head (*Cran.*), the clavicular (*Cl.*), and two or three other plates. The mandibles represent a small species, smaller than any *Titanichthys* known. It was this circumstance that led Claypole to name it *T. brevis*.

On a careful study of the mandibles it is seen that they do not belong to the genus *Titanichthys*, but to *Selenosteus*. They are similar

[1] Mem. N.Y. Acad. Sci., vol. ii, p. 101, 1910.

to those figured by Dean[1] in the type of *S. Kepleri*, except for defects in preservation, having lost their anterior extremities and the minute denticles. They differ considerably in form from the mandible figured in inner and outer aspect by Claypole in his original description, but it is impossible to say to what extent his figure is a restoration. His figures of this species are not very accurate, missing parts being restored with too much certainty and in most cases not being indicated by dotted lines. The cranium is drawn from disarticulated plates as if it were a complete specimen, and is altogether too pointed and drawn out in front. The anterior dorso-lateral is also partly restored, the posterior part being, as he says, "somewhat restored and may not be quite true to nature."

In the specimen in the British Museum (Pl. VIII, Fig. 4) the median occipital plate displays the inner aspect and closely resembles the corresponding element in *S. Kepleri*.[2] The clavicular, which was described by Claypole as a suborbital, is also preserved. It agrees exactly with the one figured by Dean.[3]

From these facts it appears that *T. brevis*, Claypole, is identical with *S. Kepleri*, Dean. The amended name of the species is *S. brevis* (Claypole).

4. Stenognathus Gouldi (Newberry). (Pl. VIII, Fig. 5, and Text-figure, Fig. 6.)

1885. *Dinichthys Gouldii*, Newberry, Trans. N.Y. Acad. Sci., p. 26.
1889. *D. Gouldii*, Newberry, Paleoz. Fishes, p. 150, pl. ix.
1889. *D. corrugatus*, Newberry, ibid., p. 151, pl. vii, figs. 3, 3*a*.
1893. *D. gracilis*, Claypole, Amer. Geologist, vol. xii, p. 279, fig.
1896. *D. Gouldi*, Newberry (ed. Dean), Trans. N.Y. Acad. Sci., vol. xv, p. 157, pl. vii.
1897. *Stenognathus corrugatus*, Newberry (ed. Dean), ibid., vol. xvi, p. 30, pl. xxiv, figs. 27, 28.
1908. *Dinichthys Gouldi*, Newberry, Hussakof, Bull. Amer. Mus. Nat. Hist., vol. xxv, p. 8, fig. 1.
1909. *Stenognathus corrugatus*, Hussakof, ibid., vol. xxvi, p. 267, fig. 4.

The writer has recently shown (1909) that the mandibles described under the names *S. corrugatus* by Newberry and *D. gracilis* by Claypole are the same, and that the genus *Stenognathus* should stand as distinct from *Dinichthys*. In the British Museum there is a specimen (P. 9335) which shows a pair of similar mandibles, and associated with them a number of disarticulated elements of the same individual, including the cranium, suborbital, maxillary, premaxillary, and several dorsal and ventral armour plates. This specimen is, therefore, of especial interest since it acquaints us for the first time with the head and body armour of the form known as *Stenognathus*. Furthermore, there are two elements in this specimen, the premaxillary and the suborbital, which are of quite distinctive form and may be told at a glance from the same elements in other Dinichthyids; and by reason of this very distinctiveness of form these elements are seen to agree closely with the corresponding ones in the specimen which was described by Newberry as *D. Gouldi*. The mandibles of the latter were represented

[1] Mem. N.Y. Acad. Sci., vol. ii, pl. vi, fig. 36.
[2] Ibid., pl. vi, fig. 33, *MO*.
[3] Ibid., fig. 38.

only by two small fragments, the anterior point of one and the posterior end of the other; and these, as far as one may judge from such fragments, indicate a very slender type of mandible quite like that of *Stenognathus*, and thus strengthen the view that *D. Gouldi* belongs in the genus *Stenognathus*.

The specimen in the British Museum is shown in the photograph (Pl. VIII, Fig. 5) and in the outline figure in the text (Fig. 6). The cranium (*Cran.*) is shown from the inner aspect. It is of about the same size as that of *D. Gouldi*. It is too imperfectly preserved to show much of the detail except the pineal foramen. The eyes in this species must have been of quite extraordinary size.

FIG. 6. Outline of bones of *Stenognathus Gouldi* (Newb.), exposed on slab shown in Pl. VIII, Fig. 5 (Brit. Mus., P. 9335). Cleveland Shale (Upper Devonian): Ohio. Explanation of letters on bones: *ADL.* anterior dorso-lateral; *AVL.* anterior ventro-lateral; *Cl.*, *Cl'.* claviculars (imperfect); *Cran.* cranium, inner aspect, and showing the pineal foramen; *DM.* dorso-median; *Mnd.* mandibles, the left in inner view, the right in outer; *Mx.* left maxilla, outer view; *P.mx.* left premaxilla, inner view; *SO.* suborbital; *x*, *x'*. fragmentary plates.

The suborbital (*SO.*) agrees entirely with the one figured by Newberry in *D. Gouldi* in his *Paleozoic Fishes of North America*, pl. ix, fig. 4.

The clavicular (*Cl.*), which is incomplete in the specimen, is somewhat different from the same element in *Dinichthys*, emphasizing the generic distinctness of this form.

The dorso-median (*DM.*) resembles the one in Newberry's specimen; but since the latter, like the one in the present specimen, lacks the anterior portion, it is impossible to compare it with Newberry's in detail. The two seem to be of about the same size.

The anterior dorso-lateral (*ADL.*) is shown in ventral aspect, and is not well preserved at the sides. It does not differ from the same element in *Dinichthys.*

The jaw elements are represented by both mandibles (*Mnd.*), the left maxilla (*Mx.*), and the left premaxilla (*P.mx.*). The mandibles are of the typical stenognathous form, that is to say, greatly elongated and very slender. The left is shown in inner aspect and the right in outer. The maxillary has a cutting edge corresponding to the elongated cutting portion of the mandible. The premaxillary is shown in inner view; it agrees almost exactly both as to size and form [1] with the corresponding element figured by Newberry in his *D. Gouldi.*

Hence it appears that the specimen which has been described as *D. Gouldi*, and the mandibles which have been described as *Stenognathus corrugatus* and *D. gracilis*, really belong to one and the same species. This should be known as *S. Gouldi*, the specific name *Gouldi* having priority.

EXPLANATION OF PLATE VIII.

Fig. 2. Small slab exhibiting a pair of mandibles, two upper dental plates (the dark elements seen in front of the mandibles) and fragments, of a small specimen of *Mylostoma*, named, in manuscript, by Dr. William Clark, *Brontichthys.* $\times \frac{1}{2}$. Brit. Mus., P. 9332. Cleveland Shale (Upper Devonian): Ohio.

Fig. 4. *Selenosteus brevis* (Claypole). Type of *Titanichthys brevis*; slightly less than $\times \frac{1}{2}$. Brit. Mus., P. 9330. Cleveland Shale (Upper Devonian): Ohio. *AVL.* anterior ventro-lateral; *Cl.* clavicular; *Cran.* left half of cranium, seen from within; *Mnd.* mandibles; *MO.* median occipital element of cranium, from within.

Fig. 5 and outline, Text-fig. 6. *Stenognathus Gouldi* (Newb.). Slab of shale showing disarticulated plates of one individual. $\times \frac{1}{3}$. Brit. Mus., P. 9335. Cleveland Shale (Upper Devonian): Ohio.

REVIEWS.

I.—The Palæontographical Society.

THE Palæontographical Society's volume for 1910, which was issued at the end of January, 1911, contains instalments of the monographs of Carboniferous and Chalk Fishes, Cretaceous Lamellibranchs, and British Graptolites, besides a small complete monograph of British Carboniferous Arachnida. It is illustrated in the usual sumptuous style by twenty-eight plates, some prepared by lithography, others by collotype process.[2] Dr. Traquair's new part of Carboniferous Palæoniscidæ is especially welcome, and the text is now as far advanced as the plates. After completing the description of *Cycloptychius*, it deals with the numerous species of *Rhadinichthys*. A new restored figure of *R. ornatissimus* is given; and Mr. James Green's

[1] In Newberry's *Paleozoic Fishes of North America* (pl. ix, fig. 2), this element is figured in outer view, but not quite correctly. It represents a second cusp which in reality does not pertain to the specimen, but is an adherent superimposed fragment. The line from the point of the tooth to the postero-lateral termination of the element is gently convex, but quite smooth.

[2] And the text-figures are very numerous throughout the volume.

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Upper Devonian Arthrodira from Ohio, U.S.A.,
in the British Museum (Nat. Hist.).

drawings of the various fossils are supplemented by useful enlarged sketches of scales by Dr. Traquair himself. Dr. Smith Woodward's contribution this year treats of very fragmentary fish-remains from the English Chalk, chiefly Chimæroid jaws and Selachian teeth, but it will prove invaluable to collectors of these fossils. It is illustrated by lithographs by Mr. A. H. Searle, and there are the usual explanatory text-figures by Miss G. M. Woodward. The comparison of the Cretaceous *Scapanorhynchus* with the existing *Mitsukurina* from Japanese seas is especially interesting. Mr. Henry Woods' monograph of Cretaceous Lamellibranchia now enters upon an account of *Inoceramus*, which is most profusely illustrated by Mr. Brock and supplies a long-felt want. The species are so numerous that those of the Chalk itself are scarcely reached in the new part, and we still eagerly await the next instalment, for which the material must now be almost overwhelming and need much study. Of the monograph of British Graptolites there is a large section, and it suffices to note that Miss Elles and Mrs. Shakespear attain their usual standard of excellence. The enlarged drawings, as before, are placed in the text, while figures of the natural size, which can be examined by a lens, occupy the collotype plates. Mr. R. I. Pocock's small complete monograph of the Terrestrial Carboniferous Arachnida of Great Britain, illustrated by numerous text-figures and three lithographic plates by Miss G. M. Woodward, is a noteworthy contribution to the volume. Mr. Pocock has industriously amassed material from all collections, and the result is truly astonishing. Much progress has been made during recent years in the discovery and description of Palæozoic Arachnids, and the restored figures which Mr. Pocock is now able to publish of several species are especially novel and interesting.

The Palæontographical Society is to be congratulated on the manner in which it continues to perform its double function of enabling stratigraphers to name their fossils, and of providing material for zoologists to compare living and extinct organisms. Subscribers appear still to be fewer than the Society needs for its full activities, and some of the plates in the new volume have been paid for by the Carnegie Trust for the Universities of Scotland. All who are interested should communicate with the Secretary, Dr. A. Smith Woodward, British Museum (Nat. Hist.), South Kensington, S.W.

II.—Extinct Monsters and Creatures of other days. By the Rev. H. N. Hutchinson, B.A., F.R.G.S., F.G.S., F.Z.S. New edition. pp. xxxiv and 330, with 55 plates and 113 text-figures. London: Chapman & Hall, 1910.

ALTHOUGH to the trained scientific observer all fossil animal- or plant-remains are interesting, it is not so with the ordinary Museum-visitor, for size and a certain resemblance to living animals appeal more to the popular imagination than incomprehensible or diminutive structures. These are the points that led Mr. Hutchinson some years ago to publish his well-known book on extinct monsters, and the necessity of bringing out a third edition showed that to his and to his publishers' great joy he had not failed to find numerous readers. Of course, the magnificent collections of the Natural History Museum facilitated this undertaking, and it is a pleasure to remark that this unique treasure-house is often referred to in the new edition.

In a review of Hutchinson's book in a scientific journal we must not look at this work merely from the evidently satisfactory commercial and general point of view, but must consider if the author has succeeded in moulding modern science into a popular form, and thus must look for the faults as well as for the merits of the work we are reviewing.

Considering the difficulty that has to be overcome to make the general reader, who knows but little of osteology, understand the structure of creatures that are only known from their bones, Hutchinson's book marks a decided success. Naturally this success could only be brought about by not entering into the discussion of open questions, but accepting a generally probable solution, and with this the critical part of the book is restricted within certain though often regrettable limits. The bulk of the book treats, of course, as most appealing to the general reader, of the different types of fossil vertebrata. After an introduction the first chapter is devoted to fossil footprints. The detailed history of their discovery in different countries is carefully given, but I believe this chapter will appear to the general reader as one of the dullest parts of the whole book, for while footprints are quite interesting as showing how indirectly even the soft parts of an animal can be preserved, I think the reader is rather indifferent as to whether a slab was found in 1828 or 1836. A comparison of the footprints of some animal with its skeletal remains, notably the work of L. Dollo on the footprints of *Iguanodon* when sitting, running, and walking, might easily have been substituted for some parts of the second chapter.

Turning to chapter iii, dealing with "Sea Scorpions", we find a great effort to make us understand these creatures, but their general structure is so unlike anything living that this portion might have been omitted were it not for the fact that it shows the public that in bygone times other monsters besides animals possessed of a backbone also existed on the earth.

Turning to the vertebrata, we can only congratulate the author. Ichthyosaurs and Plesiosaurs, even *Archægosaurus* and the stupid-looking *Actinodon*, seem to have come off quite well during their resurrection. The *Mastodonsaurus* on pl. ix, however, is decidedly feeling uncomfortable, for with its head turned skyward it seems as though it were about to sneeze at the next moment.

The chapter dealing with "Anomalous Reptiles" (Cotylosaurians, Thecodontia, and Anomodonts) gives reconstructions of *Pareiasaurus* and *Naosaurus*. Besides these instructive pictures several photographs of Professor Amalitzsky's Russian monsters are reproduced, and since these have never yet been adequately described Hutchinson's book contains in this respect some data that are of more than general interest even for the most critical scientific student.

Fully sixty-two pages deal with Dinosaurs, and give not only a very good account of many interesting discoveries but several quite up-to-date illustrations. The single figure one might object to is that of the Dinosaur pelvis (fig. 40), and here one might expect to find one of von Huene's reconstructions of Triassic forms; but, of course, all such omissions, though remarkable to a specialist dealing with Dinosaurs, are of no importance in a work of this popular character. Besides numerous drawings we find quite good reconstructions of *Ceratosaurus*, *Lælaps*, *Anchisaurus*, *Brontosaurus*, *Iguanodon*, *Claosaurus*, *Hypsilophodon*, *Stegosaurus*, and *Triceratops*. We are glad to remark that *Diplodocus*, the animal that involuntarily did so much to popularize palæontology, has been likewise reconstructed in the old-fashioned way, and not in the manner advocated recently by a German writer. Williston's drawings of different Morosauria and a modification of Osborn's *Tylosaurus* reconstructed, give quite a good general idea of the 'sea-serpents' and are dealt with in chapter x. The flying dragons (Pterosauria) have, with the exception of *Scaphognathus* (*Pterodactylus*) *crassirostris*, likewise come off quite well, but the poor *Scaphognathus* has lost the greater part of its tail somewhere (p. 203 and pl. xxxii).

Hesperornis, the Moa, and the Dodo are given as types of extinct birds; the last-named, with historical truth, is figured as a stupid, sluggish creature, easily slaughtered. If anybody objects to the reconstruction of the bad-tempered and mischievous-looking *Phororhacos*, Hutchinson can easily plead 'not guilty', for its portrait is taken from a well-known book by Professor F. A. Lucas. The mammalia are represented by *Xiphodon*, *Anoplotherium*, *Palæotherium*, outline drawings of a great many old types of 'horses', by *Coryphodon*, *Tinoceras*, *Brontops*, *Arsinoetherium* (very difficult to reconstruct), many elephants as *Mœritherium*, *Palæomastodon*, *Tetrabelodon*, *Dinotherium*, and the Mammoth. The curiosity of anybody desirous to know the principal types of mammals that formerly inhabited our globe will be gratified by reading pp. 230–90 of Hutchinson's book. One would not, however, object if in the next edition another plate were substituted for that of *Megatherium*, and if the obsolete drawing of *Diprotodon* were omitted as useless, all the more since plate iv gives the same animal in a much more complete state.

Dr. Andrews' discoveries of fossil elephants have been duly considered. Since learned palæontological books as a rule do not give the history of discoveries of fossils, and even when they do, abstain from publishing the private correspondence dealing with this question, it is a very good conclusion to Hutchinson's book to publish the correspondence that concerned one of the latest bone-bed discoveries we know of, that of 'Lake Callabona'. Even scientific people will get a glimpse in this chapter of some 'subterranean' movements that might easily be forgotten. There is a long list of literature at the end of Hutchinson's book, and for a student whose interest may well have been aroused by reading this work on extinct animals, this list will be of great value to enable him to pursue the subject further.

Gilt-edged, well-printed, and lavishly illustrated with 55 plates and 113 illustrations in the text, Hutchinson's book is brought out in a manner that Continental readers would term 'luxurious', so that it is a work likely to popularize science and well worth buying and reading.

III.—Geological Survey Memoirs.

1. The Geology of the Neighbourhood of Edinburgh. Second edition. By B. N. Peach, C. T. Clough, L. W. Hinxman, J. S. Grant Wilson, C. B. Crampton, H. B. Maufe, and E. B. Bailey; with contributions by J. Horne, W. Gibson, E. M. Anderson, and G. W. Grabham; and Petrographical Chapters by J. S. Flett. 8vo, cloth; pp. xii, 445, with 12 plates, geological map, and 19 text-illustrations. 1910. Price 7*s.* 6*d.*

2. The Geology of East Lothian, including parts of the Counties of Edinburgh and Berwick. Second edition. By C. T. Clough, G. Barrow, C. B. Crampton, H. B. Maufe, E. B. Bailey, and E. M. Anderson; with contributions on the Silurian Tableland by B. N. Peach and J. Horne. 8vo, wrapper; pp. x, 226, with 12 plates and 11 text-illustrations. 1910. Price 4*s.* 6*d.*

Printed for H.M. Stationery Office, and sold by W. & A. K. Johnston, Ltd., 2 St. Andrew Square, Edinburgh, and by T. Fisher Unwin, 1 Adelphi Terrace, London.

As these two memoirs are descriptive of adjacent areas and both are second editions, we may conveniently associate our remarks upon them.

The first edition of the Geology of Edinburgh was written by H. H. Howell & A. Geikie, and published in 1861; and that on East Lothian, the work of Howell, A. Geikie, & J. Young, was published in 1866. A long interval has thus elapsed, and both memoirs required much revision and very considerable additions. More than 330 papers on the local geology are recorded in the Edinburgh bibliography as published since 1861; and in the list we find the names of numerous local workers who have contributed papers, and of these J. Henderson and D. J. Brown are more especially mentioned in the text. The new work is, however, essentially based on observations made during the re-survey or revision of the areas on the Geological Survey maps.

The Edinburgh Memoir, which has been edited by Dr. Horne, describes the geological features of the district included in the 1 inch map 32—the first published sheet of the Geological Survey in Scotland—together with a narrow belt of ground extending from Addiewell by Bathgate to Bo'ness in Sheet 31.

In the introduction is given a brief sketch of the prominent physical features and the geological history of the region. The records of the older Palæozoic rocks, comprising the Silurian formations and the lower and upper divisions of the Old Red Sandstone, are described, a special chapter being devoted to the Petrography of the Volcanic Rocks of the Pentland Hills, of which a good pictorial view is given in a plate.

The distinctive feature of the memoir is the detailed description of the various divisions of the Carboniferous System occurring within the region, including the Oil-shale fields of the Lothians, the Carboniferous Limestone Series and associated coals of Bo'ness and Bathgate, and the Mid-Lothian basin with the Edge Coals and true Coal-measures.

The Millstone Grit or Roslin Sandstone Series was rightly mapped in the original survey as one essentially arenaceous and pebbly formation; but in accordance with the determinations of the plant and fish remains by Dr. Kidston and Dr. Traquair, the group is now considered to represent two palæontological divisions, the one Upper and the other Lower Carboniferous. It is stated that a boundary has been drawn between these subdivisions where the evidence is regarded as conclusive, but as observed (p. 244), the palæontological break is not of an absolutely definite character; two plants hitherto supposed to be confined to Lower Carboniferous in this country have since been found in Upper Carboniferous, and no stratigraphical evidence of unconformity has been detected in the series.

An interesting feature is the account of the volcanic history of the Arthur's Seat Volcano, and the special description of the petrography of the Carboniferous volcanic rocks of the Edinburgh and Linlithgow districts. Three excellent pictorial plates and a coloured geological map illustrate the geological features of Arthur's Seat. Moreover, we learn that "The re-examination of Arthur's Seat by the Geological Survey confirmed the later views of Charles Maclaren and the conclusions of Professor Judd regarding its structure, namely, that the lavas and ashes, together with the central agglomerates and their associated igneous rocks, belong to one period of volcanic activity".

The formations newer than the Coal-measures are all included under the heading of Pleistocene and Recent. They comprise Boulder-clay, Glacial sands and gravels, ancient lake-deposits with Arctic plants, raised beaches, and alluvial terraces. Evidence furnished by certain buried river channels indicates that in pre-Glacial time the land stood higher relatively to the sea than at present. In connexion with the Glacial phenomena, of special interest is a transported mass of igneous rock resting on Glacial sands and gravels at Comiston. This is illustrated in one of the plates.

The economics of the region are fully discussed. Tables are given showing the thickness, class, and quality of the various coal-seams in the Mid-Lothian basin and in the Bo'ness and Bathgate districts, and chemical analyses of various seams are quoted. A table is also given showing the physical properties of the more important building-stones of the region, and an account is presented of the water-supply of Edinburgh and the surrounding districts.

In the appendix appears a general list of Carboniferous fossils arranged in their systematic order, and this is preceded by notes on the distribution of life in the Lower Carboniferous rocks. There are also lists of Pleistocene and Neolithic organic remains.

2. The East Lothian or Haddington Memoir describes the Geology of East Lothian and the coastal belt near Cockburnspath in the adjacent county of Berwick. The introduction presents a synopsis of the rock groups and their distribution and an account of the physical features and their development. Brief descriptions are next given of the Silurian rocks of the Lammermuir Hills and of the Upper Old Red Sandstone, the latter formation in this region being associated with the classic generalizations of Hutton and of his associates, Playfair and Sir James Hall.

The greater part of the memoir is occupied by detailed descriptions of the Carboniferous rocks ranging from the Calciferous Sandstone

Series to the true Coal-measures. An interesting feature of the memoir is the history of the contemporaneous volcanic rocks of the Garleton Hills and the associated igneous intrusions, including the trachytic masses of North Berwick Law, the Bass Rock, and Traprain Law. A full account is given of the petrology of these volcanic rocks and associated intrusions; and views are given in plates of the Bass Rock and the rocks of Dunbar Castle.

The records of the Glacial period, and, in particular, the glacial drainage channels connected with the retreat of the ice-sheet, are passed in review, particulars and some illustrations being reproduced from the interesting paper by Professor P. F. Kendall and Mr. E. B. Bailey (Trans. Roy. Soc. Edin., noticed in Geol. Mag., May, 1908, p. 231).

In the chapter on Economics particulars are given of the coals, fireclays, building-stones, agriculture, and water-supply. Lists of Carboniferous fossils are given in an appendix.

The two 1 inch geological maps described in the memoirs are Sheets 32 and 33, excellently colour-printed, and issued each at the price of 2*s.* 6*d.*, instead of 13*s.* 3*d.* and 10*s.* 3*d.*, the later prohibitive prices put on the hand-coloured maps by H.M. Treasury. An enormous amount of detail is shown largely by symbols among the igneous rocks, thirty tablets being devoted to them in the Index of Colours. The Glacial Drifts are not distinguished by colour, but only by engraved symbols.

3. The Geology of Glenelg, Lochalsh, and South-East part of Skye. By B. N. Peach, J. Horne, H. B. Woodward, C. T. Clough, A. Harker, and C. B. Wedd; with contributions by G. Barrow, J. J. H. Teall, J. S. Flett, and F. L. Kitchin. Edinburgh: printed for H.M. Stationery Office, and sold by W. A. K. Johnston, Ltd., 2 St. Andrew Square, and T. Fisher Unwin, 1 Adelphi Terrace, London. 8vo, wrapper; pp. x, 206, with 13 plates and 13 text-illustrations. 1910. Price 3*s.* 6*d.*

THIS memoir, one of the more elaborate of those issued by the Scottish branch of the Geological Survey, has been edited with great precision by Mr. Clough. It is descriptive of Sheet 71, which we are pleased to see in colour-printed form and issued at the price of 2*s.* 6*d.* Although it has no less than seventy-five tablets to represent geological formations and subdivisions, the map clearly displays the main structure of the ground, the Glacial drifts being uncoloured and indicated by signs, although by no means unimportant from an agricultural point of view.

The most ancient rocks are exposed on the eastern and southern portions of the area, in parts of the mainland of Ross and Inverness and the south-east of Skye. They are described by Messrs. Horne, Peach, and Clough. The oldest group, the Lewisian gneiss, includes thick layers of limestone, graphitic bands, and some gneisses of sedimentary origin. The Moine schists, "of uncertain age," but regarded as a newer group, give evidence pointing to the conclusion that the Moine sediments were laid down unconformably on the

Lewisian, and that the schists may be altered representatives of Torridonian strata. The effects produced by the Moine thrust, of Post-Cambrian date, and by other movements are illustrated by sections and many excellent plates.

The Torridon Sandstone, which is reckoned to be about 14,000 feet thick, occupies prominent belts in South-Eastern Skye and on the Ross-shire coast north of Kyle Akin; it occurs also in other parts of Skye and over the greater parts of Scalpa and Longay. The highest portion of the series appears in the Crowlin Islands. It is remarked that all the Torridonian rocks are probably in a thrust condition, and that the Cambrian strata have nearly all been formerly covered by Torridonian rocks, carried forward by thrusts. The various Cambrian divisions are described; *Olenellus* is recorded from the 'Fucoid Shales' of Ord Bay, and many fossils from the Durness Limestone, south of Broadford. 'Skye marble,' which was formerly worked in Strath Suardal, is now quarried to the north-west of Broadford, and it is hoped that it "may be found suitable for most of the purposes for which Italian marble is now used".

The Triassic rocks, comprising red and mottled sandstone marl and conglomerate, are well seen near Broadford and Heast, and in Raasay, and they are surmounted by passage-beds no doubt of Rhætic age, as indicated by fossils obtained by Messrs. Woodward, Wedd, and D. Tait. The Lower and Middle Lias of Broadford, Pabba, and Scalpa were well-known to previous observers, who noted the coral-beds with *Isastræa* and *Thecosmilia* and the fossiliferous shales with many Ammonites (*Jamesoni* and other zones) on Pabba and elsewhere. The headland between Loch Slapin and Loch Eishort affords good sections of the Pabba shales, as described by Mr. Barrow. In the district of Strathaird much new information has been gathered by Mr. Wedd, who has determined the sequence to range from the top of the Middle Lias to the Oxfordian and Corallian—with the absence apparently of the *Ornatus*-beds of the Oxfordian. Apart from some traces of Kellaways Beds the mass of the Oxford Clay belongs to the *Cordatus*-zone, and the strata, which consist of sandstones and shales, pass upwards into shales with Corallian fossils. This latter horizon was not separated on the map as the evidence at the time was not conclusive. The discovery by Mr. Wedd of Upper Cretaceous (Cenomanian) at Strathaird and Strollamus on Skye and on the south of Scalpa is of great interest. He considers that the Jurassic rocks were subjected to considerable earth-movements prior to the deposition of the Upper Cretaceous.

The Tertiary igneous rocks of the eastern Cuillins with Blathbheinn (Blaven) and the Red Hills have been described in a special memoir by Mr. Harker (1904), and a summary only of the leading facts and conclusions is now given. To Mr. Harker also we are indebted for a luminous essay on Ice-Erosion in the Cuillin Hills (noticed in the Geological Magazine for January, 1902, p. 35), so that this most interesting subject is dealt with less fully in the memoir than it otherwise might have been. The final chapters treat of raised beaches, recent deposits, and economics; and there are palæontological and bibliographical appendices.

4. The Geology of the Country around Padstow and Camelford. By Clement Reid, G. Barrow, and Henry Dewey; with contributions by J. S. Flett and D. A. MacAlister. London: printed for H.M. Stationery Office, and sold by E. Stanford, Long Acre, and T. Fisher Unwin, 1 Adelphi Terrace. 8vo; pp. vi, 120, with 4 plates and 7 text-illustrations. 1910. Price 2*s.* 3*d.*

THIS memoir has been written in explanation of Sheets 335 and 336 of the New Series Geological Survey map of England. The area thus takes in portions of the north Cornish coast, from the famous Bedruthan Steps to Trevose Head and Harlyn Bay, Padstow, Pentire Point, and Port Isaac; it includes also the little towns of Wadebridge and Camelford, and a large part of Bodmin Moor. The maps show, for the first time, the divisions of Lower, Middle, and Upper Devonian, but it must be confessed that the colouring of the Upper Devonian slate is so nearly like that of the Middle Devonian that the distinction is not apparent without a close inspection. The physical features of Bodmin Moor are made manifest by the mapping of the Alluvium and Peat, which are separately coloured in the Index tablets but not on the map. An important addition is the indication of the petrological characters of the metamorphic aureole surrounding the Bodmin granite. There the altered Devonian rocks include sundry schists, and also calc-flintas "where the calcareous rocks have been converted into insoluble lime-silicates".

The Lower Devonian rocks have yielded but few fossils, including *Homalonotus*; in the Middle Devonian slates, thanks to the painstaking labours of Mr. Howard Fox, many fossils have been found, and notably species of *Pteraspis* and *Scaphaspis*; while to Mr. Fox again, who discovered the Büdesheim fauna in Trevone Bay, our knowledge of the Upper Devonian fossils is chiefly due. The specimen of *Homalonotus Barratti*, which was found by Mr. Walter Barratt and described by Dr. Henry Woodward, is referred to the Upper Devonian of Mother Ivey's Bay (not Porthcothan). Important additions to the lists of fossils have been made during the progress of the Geological Survey, especially from the Upper Devonian of Port Quin, where many specimens were collected and developed by Mrs. Clement Reid.

The contemporaneous volcanic rocks, spilites, schalsteins, and tuffs have been separated from the 'greenstones' or diabases The pillow-lavas, grouped as spilites, were described by Messrs. Reid and Dewey in a paper published by the Geological Society, and although particulars are given in the memoir, it is to be regretted that the illustrations of these remarkable and interesting features have not been reproduced. In connexion with the subject Dr. Tempest Anderson's account of the formation of pillow-lava in Savii, one of the Samoa Islands (Q.J.G.S., lxvi, p. 632, 1910), may be read with advantage.

Particulars are given of the granites, elvans, and minettes, and of the thermometamorphism surrounding the granite. An excellent view of Roughtor illustrates the characters of tors that "are built up of lenticular blocks or sheets of granite".

Attention is drawn to the features of Pliocene and earlier age, to the Raised Beaches and River Terraces, and to the connexion between the amount of superficial deposits and the history of the valleys.

Special interest attaches to the Stream Tin and Wolfram Deposits, and we wonder why the illustrations of these deposits, of so much practical as well as general interest, are not reproduced from the paper communicated to the Geological Society in 1908 by Mr. Barrow. To the greater number of residents it is probable that the subject would be more attractive than the petrographical descriptions (important as they are) which occupy nearly half the memoir.

In the chapter on Economics there are accounts of the famous slates of De la Bole, of the Cataclews rock (proterobase), the De Lank granite, and the China clay, the metal-mining, and water-supply.

Reference is made to the ancient British cemetery at Harlyn Bay, and mention might appropriately have been made, in a footnote, of the pamphlet by the Rev. R. Ashington Bullen on "Harlyn Bay and the discoveries of its Prehistoric Remains", 2nd ed., 1902.

IV.—English Provincial and Scottish Geological Societies.

Liverpool Geological Society.—The Proceedings of this Society (vol. xi, pt. i, 1910) contain a brief account of the celebration of the Society's Jubilee, and the Address which Professor J. W. Judd delivered on that occasion on "The Triumph of Evolution: a retrospect of Fifty Years". This subject has been more fully dealt with by him in a recently published work entitled *The Coming of Evolution*. Mr. T. H. Cope writes "On the Recognition of an Agglomerate"; and Mr. C. B. Travis gives particulars of some borings carried through Glacial Drift into Keuper and Bunter Sandstones near Burscough, north of Ormskirk. He draws attention to the evidence of a buried pre-Glacial valley. In one boring the Drift was 240 feet thick.

Liverpool Geological Association.—In the part of the Proceedings (New Series, No. 4, 1910) which contains records of the sessions 1907–9, Mr. C. B. Travis gives some useful hints on "Field Work among Igneous Rocks"; Mr. J. G. Learoyd deals with "Pressure in relation to Thickness of Ice"; Mr. T. A. Jones discusses the "Augite Porphyrite" of Scarlett Stack, Isle of Man, a rock which he regards as a decomposed basalt and the remnant of a lava-sheet; and Mr. H. W. Greenwood considers "Some Problems in Rock Genesis and Metasomatism".

Yorkshire Geological Society.—In the well-illustrated Proceedings of this Society (n.s., vol. xvii, pt. ii, 1911) Dr. Wheelton Hind describes four new species of Nautiloids, including one new genus, *Cyclonautilus*, also one Goniatite, *Glyphioceras vesculifer*, de Kon., from the Carboniferous rocks of Yorkshire and Lancashire; Mr. Frank W. White gives a detailed account of the complex of igneous rocks at Oatland, Santon, Isle of Man, with micro-sections of the rocks; Mr. E. A. Newell Arber contributes an article on the Fossil Flora of the Coalfield in North Derbyshire and Nottinghamshire, illustrated by eight excellent plates of fossil plants; and Mr. G. W. Lamplugh has written obituary memoirs (with portraits) of C. Fox-Strangways and J. R. Dakyns.

Hull Geological Society.—The Transactions of this Society, vol. vi, pt. ii, contain the record of work done during the years 1906–9; and include papers on the Fossil Cephalopoda of the

Holderness Drift, and on the Belemnites of the Yorkshire Lias, by Mr. C. Thompson; on the Pleistocene fossiliferous beds of Bielsbeck, near Market Weighton, by Mr. J. W. Stather; together with miscellaneous notes and a useful geological bibliography for E. Yorkshire and N. Lincolnshire, 1906–9, by Mr. T. Sheppard.

Edinburgh Geological Society.—The Transactions of this Society (vol. ix, pt. v, 1910) contain, among other articles, papers by Dr. S. J. Shand on some Scottish granite-gneiss contacts in the counties of Aberdeen and Argyll, and on Borolanite and its associates in Assynt, with chemical analyses by Mr. A. Gemmell. Dr. Shand calls attention to evidence that favours the theory of assimilation of lime from underlying Cambrian Limestone in portions of the igneous complex of Cnoc-na-Sroine in Assynt. Numerous illustrations accompany these papers.

Glasgow Geological Society.—The Transactions of this Society (vol. xiv, pt. i, 1910) open with the Address of the President, Professor J. W. Gregory, who selected for his subject "Work for Glasgow Geologists: the Problems of the South-Western Highlands". He gives an interesting and instructive account of the work of the many geologists who have laboured among the schistose rocks of Argyllshire and Perthshire, and of the numerous difficulties and problems involved in their study. As an aid to further research he has drawn up a table showing the geographical succession and geological correlation of the various Dalradian rocks, remarking in advance that "two of the chief present riddles of Scottish geology are, what is the age of this Dalradian System, and which is the top and which is the bottom of its long succession of deposits?"

The Carboniferous rocks of the Solway borders are described by Mr. John Smith, who deals very fully with the fossils, and describes some new species of sponges, turbellaria, annelids, etc. His paper is illustrated by eight plates. Mr. R. G. Carruthers deals with zonal work in Lower Carboniferous rocks and on the collecting of fossils; and Mr. R. Dunlop gives an account of the fossil Amphibia in the Kilmarnock Museum previous to the fire of 1909. It is satisfactory to learn that a good many fossils have been recovered from the debris of that disastrous fire.

V.—Brief Notices.

1. Some Features of Alpine Scenery.—In an interesting and well-illustrated essay Professor E. J. Garwood has drawn attention to "Features of Alpine Scenery due to Glacial Protection" (*Geograph. Journ.*, September, 1910). As he remarks at the outset, "No one with any knowledge of glaciated regions doubts that moving ice erodes," but his object is to bring forward evidence to show that ice, on the whole, erodes less rapidly in the Alps than other denuding agents, and under certain conditions may act as a protective agent.

2. Ice on Canadian Lakes.—This subject is dealt with by Mr. J. B. Tyrrell (Trans. Canadian Inst., ix, 1910), whose observations establish the following points. In regions of heavy snowfall the ice is being constantly pressed down into the water by the weight of snow, and therefore there is often water over it and beneath the snow. In these

regions the ice increases in thickness mostly from the top, by the freezing of the overflowing water; but in other regions of light snowfall it increases mostly from the bottom. Throughout the winter the ice remains firmly frozen to the shore, except that it falls with the lowering of water in the lakes. In the spring it thaws along the shore, and around any stones. Loose ice floating on the water is then pushed against the shore by wind, and sand and stones are thrust up by and in front of it, often to the back of the beach, and there piled into rough and heavy walls or ramparts.

3. Beekite.—An article on this form of orbicular chalcedony is contributed by Mr. W. H. Wickes (Proc. Bristol Nat. Soc., 1910). Named after Henry Beeke, Dean of Bristol (born in 1751 and died in 1837), who first called attention to the mineral, the original describer appears to be unknown. After dealing as far as possible with references to the same mineral substance, dating back to 1751, Mr. Wickes gives a list of formations and fossils showing how widely distributed are the incrustations of Beekite, from an *Orthoceras* in the Cambrian Limestone of Durness to the Norwich Crag. It occurs only on marine calcareous organisms, and in the opinion of the author the material has been deposited from silica in solution in sea-water, in and around cavities produced in the shells and other organic structures by boring animals.

4. Catalogue of Photographs of Geological Subjects, prepared by the Geological Survey and Museum. 8vo; pp. 62. Price 6*d.* Edinburgh, 1910.—This work, issued as a memoir of the Geological Survey of Scotland, supplements that relating to England and Wales, which was noticed in the Geological Magazine for July, 1910, p. 330. The Scottish Survey has been longer engaged in the taking of photographs of geological interest, and the number now catalogued amounts to 676 whole-plate and 1,237 half-plate subjects, as against a total of 800 in the English collection. Among the Scottish subjects, of which brief descriptions are given in the Catalogue, are many features in the Lewisian gneiss, Torridonian, and Cambrian (including great thrusts), Ordovician, Carboniferous, Triassic, and Jurassic. The igneous rocks of Skye, Arran, Argyll, and Ayr are well illustrated; likewise glacial phenomena, landslips, screes, faults, arches, caves and various forms of weathering, peat-mosses, etc. Negatives, prints, lantern-slides, and bromide enlargements of any of these photographs can be obtained at a fixed tariff, on application to the Director, Geological Survey, either at 33 George Square, Edinburgh, or at 28 Jermyn Street, London.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

1. *January* 25, 1911.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communication was read:—

"The Skomer Volcanic Series (Pembrokeshire)." By Herbert Henry Thomas, M.A., B.Sc., F.G.S.

This series of volcanic rocks is developed in the west of Pembrokeshire, and takes its name from the island of Skomer, where the maximum thickness is exposed. The rocks are traceable on the mainland from near St. Ishmaels on Milford Haven to Wooltack Head, and on the west occupy the islands of Midland, Skomer, and the Smalls. The thickness exposed is some 3,000 feet, and the lateral extension some 25 miles. The district described is that portion of the mainland known as the Wooltack Peninsula, and the islands on the west. The chief evidence bearing on the age of the series is obtainable from the mainland sections, and indicates that the rocks are of pre-Upper Llandovery age; but, from a consideration of the geology of the neighbouring country, it is probable that their true age is Arenig. The rocks are chiefly subaërial lava-flows of extreme thinness and great lateral extent; they are frequently interstratified with red clays, and are separated into two main groups by a thick mass of sedimentary rocks barren of fossils. There is an almost complete absence of pyroclastic rocks, a fact which points to the eruptions being of the fissure type.

The lavas form well-defined groups in the field, and range from extremely acid varieties with a silica percentage of about 80 to others with a percentage of less than 50. The rocks of the series fall into eight chief types, two of which are of necessity new; in order of increasing basicity they are as follows: soda-rhyolites, soda-trachytes (including olivine- and hypersthene-bearing varieties), keratophyres, skomerites, marloesites, mugearites, olivine-basalts, and olivine-dolerites. The last-named are probably intrusive. All these types are described in the paper, and several analyses are tabulated. The first five types may be included in the alkaline class; they are rich in soda, and most of the felspars belong to albite-oligoclase varieties. The last three types are normal sub-alkaline rocks, in which the felspars range from oligoclase to labradorite.

The author does not consider that the Skomer rocks have been albitized to a sufficient degree to mask their original characters, and regards them as a mixture of alkaline rocks of Pantellerian affinities, with a subordinate series of more basic sub-alkaline rocks, the most basic of which are probably intrusive.

At 7 p.m., before the Ordinary Meeting, a Special General Meeting, at which 92 Fellows were present, was held in order to consider the resolutions submitted to them by the Council (see GEOL. MAG., February, p. 94).

Resolutions *a*, *b*, and *d* were carried unanimously, and Resolution *c* was carried by 57 Ayes to 10 Noes.

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2. *February* 8, 1911.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

Professor T. W. Edgeworth David, C.M.G., D.Sc., F.R.S., F.G.S., gave an account of the researches pursued by him in conjunction with Mr. R. E. Priestley, Geologist to the British Antarctic Expedition of 1907–9, in the course of that expedition, more especially the investigations connected with glacial geology. The lecture, which was illustrated by a series of beautiful lantern-slides and by numerous rock-specimens collected from the Antarctic continent, was followed by a discussion, in which Sir Ernest Shackleton, Professor P. F. Kendall, Mr. G. W. Lamplugh, Mr. Clement Reid, Dr. Tempest Anderson, and Professor E. J. Garwood took part.

II.—Mineralogical Society.

January 24, 1911.—Prof. W. J. Lewis, F.R.S., President, in the Chair.

F. H. Butler: On Kaolin. The kaolinite in the Glamorganshire Coal-measures originated in the decomposition of felspar by carbonated underground water. The secondary mica and quartz of the Carboniferous grits and greisens are due primarily to the formation of potassium carbonate and alumohexasilicic acid (Morozewicz), the acid breaking up into silica and alumdisilicic acid (i.e. kaolin less water of crystallization) and the latter combining with the carbonate to yield muscovite and free carbonic acid. Kaolinite is destroyed concurrently with the growth of schorl in kaolin-rock, and cannot therefore be a product of boration.—Dr. G. T. Prior and Dr. G. F. H. Smith: On Schwartzembergite. Analyses recently made by the former show that this mineral is a complex iodate and oxychloride of lead, $Pb(IO_3)_2\ 3[PbCl_2 . 2PbO]$.—A Hutchinson: An improved form of Total Reflectometer. The instrument is a goniometer of the suspended type, with a large base plate, to which a telescope and collimator, a microscope bisecting the angle between them, and other apparatus can be clamped, and is intended for the measurement of minute crystals, and the determination of the optic axial angle of biaxial crystals and of the refractive indices by Kohlrausch's method.—T. Crook: A case of Electrostatic Separation. The apparatus consists of two copper plates, one of which is coated on one side with a layer of shellac. Good conducting minerals are attracted to the shellac-covered surface of the upper plate when it is charged by means of an electrophorus.

III.—Zoological Society of London.

February 7, 1911.—Professor E. A. Minchin, M.A., Vice-President, in the Chair.

Dr. C. W. Andrews, F.R.S., F.Z.S., exhibited a skull of a Sabre-toothed Tiger (*Smilodon Californicus*) from an asphalt deposit in California, and pointed to anatomical characters which tended to prove that the animal used its large canines for stabbing and tearing, not for biting.

Professor J. Cossar Ewart, M.A., F.R.S., F.Z.S., gave an account of his memoir entitled "Skulls of Oxen from the Roman Station at Newstead, Melrose", illustrating his remarks by lantern slides. He stated that examination of the skulls from Newstead lent support neither to the descent of all European cattle from the Urus (*Bos primigenius*) nor to the descent of all European, Indian, and African breeds from the Asiatic Urus (*B. nomadicus*). He dealt with the evidence to be derived from the maxillæ, the occiput, and the temporal fossæ, and stated his conclusions as follows:—

1. That the Celtic Shorthorn (*B. longifrons*) is probably more intimately related to the Zebu of India (*B. indicus*) than to the European Urus (*B. primigenius*).

2. That long premaxillæ are usually correlated with an occiput of the *B. primigenius* type, while short premaxillæ are usually correlated with an occiput of the *B. acutifrons* type.

3. That polled black Galloway cattle and polled white 'wild' Cadzow cattle are intimately related to the Urus, that flat-polled Aberdeen-Angus cattle probably include amongst their ancestors an ancient Oriental race now represented by, amongst others, a Syrian breed with rudimentary horns, and that round-polled cattle may belong to a still more ancient Oriental race descended from *B. acutifrons* of the Punjab Siwaliks.

CORRESPONDENCE.

LATERITE IN BRITISH GUIANA.

Sir,—I notice with regret that there are several typist's errors in the last part of my laterite paper. Some uncorrected pages of typescript appear to have been sent to you in place of the corrected ones which I have here. The errors are all in the December Number, 1910.

Page 559, line 20, *read* it *for* them.
p. 559, l. 27, *read* tropics *for* Indies.
p. 560, l. 18, *insert* the nature *before* of which.
p. 560, l. 38, *read* alluvial *for* alkaline.
p. 560, l. 41, *read* and is resistant *for* which is resistant.
p. 561, footnote, l. 2, *read* rocks *for* rock.
p. 561, footnote, l. 5, *insert* boiled *between* recently *and* distilled.
p. 561, footnote, l. 13, *delete* then.
p. 561, footnote, l. 14, *read* and *for* or in.
p. 561, footnote, l. 16, *read* experiment *for* experiments.
p. 561, footnote, l. 18, *read* showed the action *for* show it.
p. 562, l. 2, *read* silica *for* silicate.
p. 562, l. 3, *read* into *for* with.

I regret that these slips should have occurred in my MS.

J. B. Harrison.

Science and Agriculture Department,
Georgetown, Demerara, British Guiana.
January 6, 1911.

HIGH-LEVEL SHELLY GRAVEL.

Sir,—With reference to my letter in the Geological Magazine for January, and a reply by Mr. Lamplugh in the February number, I hasten to assure Mr. Lamplugh that I have never regarded him as a "docile" glacialist. On the other hand, I have long been duly impressed with his restiveness; and if the phrase "docile glacialist" is to some extent a contradiction in terms, Mr. Lamplugh is quite justified in claiming that he has done his best to make it so.

I must, however, reassert my statement that the 'land-ice' glacialists, including himself, have advocated a conception of glacier-progression which is quite inadequate to explain the transportation of gravel to high levels. If I may again state this crude conception briefly, it is that the front of the ice-sheet is pushed bodily uphill, carrying morainic material with it. The fact that this has been seen to take place on a small scale at the tip of a thin ice-lobe is, as Professor Bonney has remarked, not sufficient to justify the view that this is the manner in which gravels have been transported by ice to high levels.

Professor Bonney quotes Professor Kendall as saying that there is "no logical halting-place between an uplift of ten or twenty feet to surmount a *roche moutonnée*, and an equally gradual elevation to the height of Moel Tryfaen". Mr. Lamplugh is surely referring to the same bodily upbending of the front of an ice-sheet when he writes of "the characteristic upturning of the layers of ice at the end of one of the glacial lobes", as observed by Professor R. D. Salisbury in Greenland (York Address, Brit. Assoc. Rep., 1906, p. 543).

Nowhere in his writings, as far as I know, does Mr. Lamplugh recognize the importance of overthrust in ice-movement, as this has been described by Professor T. C. Chamberlin, and amplified later by Professors Garwood and Gregory (Q.J.G.S., vol. liv, 1898). I think Mr. Lamplugh cannot have read my letter with sufficient care, or he would not have considered it to be a mere repetition of views previously advanced and duly appreciated by him.

It seems to me that the land-ice hypothesis would get along much better if we heard rather less of "the characteristic upturning of the layers of ice at the end of the lobes", and rather more of the upthrust action in the main body of the ice, as demonstrated by Professors Chamberlin, Garwood, and Gregory; and I am pleased that I have been able to elicit from Mr. Lamplugh a plain repudiation of what is obviously a crude conception.

T. Crook.

MISCELLANEOUS.

Iron-ore in Raasay.[1]

The recent announcement of the discovery of a valuable deposit of iron-ore in the Island of Raasay has been received with the greatest interest in iron and steel trade circles in the West of Scotland. The deposit was originally discovered in 1893 by Mr. H. B. Woodward, F.R.S., F.G.S., of the Geological Survey, who contributed an instructive article on the subject to the Geological Magazine[2]; but the credit of investigating it in the interests of commerce belongs to Mr. Wallace Thorneycroft, who has been engaged in preliminary exploring work in the island during the greater part of last year. It is reported that Messrs. William Baird & Co., Limited, iron-masters, of Gartsherrie, have purchased the island from Mrs. Wood, the present proprietrix, with the view of further proving and developing the property. The deposit is situated at the junction of the Upper and Middle Lias, which corresponds approximately with the geological position of the Cleveland ironstone. On the eastern

[1] From the *Glasgow Herald*, December 31, 1910.

[2] "On a Bed of Oolitic Iron-ore in the Lias of Raasay": Geol. Mag., November, 1893, p. 493. See also British Association Reports, Section C (Geology), Nottingham Meeting.

shore of the Island of Skye the Upper Lias crops out, and though bands of ferruginous limestones are referred to by Bryce and other geologists as being visible south of Portree, ironstone proper has not yet been discovered in place except in Raasay. Some fairly good loose stone has, however, been met with some miles north of Portree, and it is possible that future boring may disclose the presence of the deposit in the north of Skye.

A Typical Analysis. The Raasay deposit is from 6 to 17 feet thick, and tails out into limy bands. Some interesting specimens of the stone have been presented by Mr. Thorneycroft to the metallurgical museum of the West of Scotland Technical College. A typical analysis of the ore in bulk is as follows, the corresponding figures of the average of Cleveland ironstone being given for purposes of comparison:—

	Raasay.	*Cleveland.*
Ferrous oxide	30·3	32·5
Ferric oxide	2·3	3·0
Manganese oxide	·4	·7
Alumina	5·6	10·2
Lime	17·6	5·0
Magnesia	2·0	3·5
Carbon dioxide	28·3	19·0
Silica	6·5	13·5
Sulphur	·2	·2
Phosphoric acid	2·3	1·0
Water, etc.	4·5	11·4
	100·0	100·0
Iron in raw	25·2	27·38
Less by calcining	29·5	26·39
Iron in calcination	35·7	37·2
Specific gravity	2·83	2·86

It is suggested now that rather than erect blast furnaces in the island Messrs. William Baird & Co. may calcine the ore (many millions of tons of which will, it is reported, be available) in Raasay, and ship the calcined ore to their works at Gartsherrie. As will be seen from the analysis, the ore is of a good basic kind, and in these days when the basic Bessemer furnace is used largely for making steel suitable for sheet and tinplate rolling, the adoption of a plan such as has been indicated would be of the greatest service to the West of Scotland, where there are a great many sheet and bar rollers who do not make their own steel, and who are largely dependent upon foreign imports. With a large supply of cheap ore, Messrs. William Baird & Co. would find themselves in a position to manufacture at a price which would effectually keep out the foreigner.

There seems to be no doubt that a much-needed source of supply of iron-ore in vast quantities has been discovered, and important as the possible benefits that may accrue to the iron and steel trades of the West of Scotland are, the beneficial results of the establishment of mining works on an extensive scale in the Western Isles, which will give work to large numbers of men in a district where little employment has hitherto been obtainable, cannot be overestimated.

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HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

ASSISTED BY

PROFESSOR J. W. GREGORY, D.Sc., F.R.S., F.G.S.

DR. GEORGE J. HINDE, F.R.S., F.G.S.

SIR THOMAS H. HOLLAND, K.C.I.E., A.R.C.S., D.Sc., F.R.S., F.G.S.

PROFESSOR W. W. WATTS, Sc.D., M.Sc., F.R.S., PRES. GEOL. SOC.

DR. ARTHUR SMITH WOODWARD, F.R.S., F.L.S., SEC. GEOL. SOC., AND

HORACE B. WOODWARD, F.R.S., F.G.S.

APRIL, 1911.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VIII.

No. IV.—APRIL, 1911.

ORIGINAL ARTICLES.

I.—NOTES ON BRITISH DINOSAURS. PART IV: *STEGOSAURUS PRISCUS*, SP. NOV.

By Baron FRANCIS NOPCSA.

(WITH NINE ILLUSTRATIONS IN THE TEXT.)

(*Concluded from the March Number, p. 115.*)

Limb-bones.—Since the humerus is known in *Hylæosaurus* (?), *Omosaurus*, and *Stegosaurus*, it is quite easy to compare the humerus of our new species with that of the other genera mentioned. Whether the shaft is hollow as in *Omosaurus* or solid as in *Stegosaurus*, cannot be ascertained without breaking the specimen; the outline of the new humerus is, however, that of *Omosaurus*, not that of *Stegosaurus*.

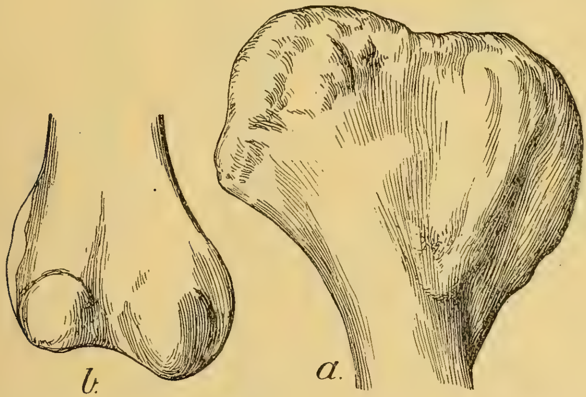


FIG. 4. Humerus of *St. priscus*. *a.* Posterior view of proximal end. *b.* Anterior view of distal end.

The proximal condyle was situated, as far as can be made out, much as in *O. armatus*, and the radial crest shows also the same curve as in this species; the anconeal ridge, however, is more strongly developed, and ends distally in a broad rugose area somewhat above the middle of the bone (Fig. 4*a*). The anconeal depression and the trochlear groove (visible in Fig. 4*b*) are less marked in *St. priscus* than in *O. armatus*. The ridge for the supinator is broken off in the new specimen, but if preserved it would give to the distal part of the bone a rather dilated aspect, and thus produce a certain resemblance to *St. ungulatus*.

Though the humerus we are considering has been somewhat flattened by crushing, the inward bend of the radial crest does not seem to have been as strong as in the humerus referred by Hulke to *Hylæosaurus*, with which it might otherwise be well compared. The total length of the humerus is 50 cm.

The ulna of *O. armatus* is too much mutilated to be compared with the same bone in *St. priscus*. If, however, we compare the ulna of *Stegosaurus*, we find that it is less dilated at the proximal end and that its shaft is much more slender (Fig. 5). The length of the ulna from the humeral articular surface to the distal end is 40 cm.

A large irregular flattened bone of somewhat parallelopiped shape, the structure of which would indicate that it was almost completely covered by a thin layer of cartilage, may be regarded as a proximal carpal, though from lack of comparative material its position cannot yet be determined with precision.

Fig. 5. Ulna of *St. priscus*.

According to Marsh separate carpals characterize the genus *Diracodon*, and this would tend to indicate a close affinity between our *Stegosaurus* and this genus, but I am quite open to the suggestion that such a fusion of carpals in some Dinosaurs may be due only to old age, and hence may not have either generic or even specific value.

The femur of the new *Stegosaurus* (Fig. 6*c*) is a long, straight, and rather slender bone, somewhat compressed from back to front at each end, and showing a well-developed articular surface suggestive of that in the femur of a chicken in which the epiphyses are not yet fused with the bone or have been artificially removed by roasting and boiling afterwards. The articular surfaces on the femur of *St. priscus* are not flat but rugose, and show irregular grooves and furrows resembling those of the bone-surface to which the epiphysis is attached in birds and mammals. The manner in which these surfaces pass into the rest of the bone is likewise the same as in the strongly macerated chicken just mentioned. The lack of a pit for the attachment of the ligamentum teres is another noteworthy feature of *St. priscus* and all Stegosauridæ, and the whole character of the articular surface is entirely different from that of the Ornithopodous femur where a pit for the ligamentum teres is indicated. To show the differences here referred to, a strongly macerated femur of *Gallus*

FIG. 6. Femora of various animals. *a*. Strongly macerated femur of *Gallus*. *b*. Non-macerated femur of the same. *c*. Femur of *St. priscus*. *d*. Femur of *Hypsilophodon Foxii*.

(Fig. 6*a*) and another which has not been macerated (Fig. 6*b*), besides a well-ossified femur of *Hypsilophodon* (Fig. 6*d*), showing the pit for the ligamentum teres, and the femur of *St. priscus*, have been drawn together of equal size in Fig. 6, and it is thus easy to see between which bones there is the greater resemblance. I do not wish to imply by pointing to these similitudes that *Stegosaurus* had separate epiphysial bones, but I wish to emphasize the fact that in this genus the amount of cartilage on both ends of the femur was decidedly much greater than in the Ornithopodidæ, and that the shape of the proximal and distal end of the bone must have been originally somewhat different from the present shape. The lack of a trochlea on the distal end of the femur of *Stegosaurus* can give us a clue to the amount of cartilage missing, for *Stegosaurus*, being a terrestrial animal, cannot have walked, and especially sat down without bending its knees sometimes for more than 90 degrees, while as shaped in the fossil the tibia would become dislocated if forced to make an angle of more than 45 degrees with the femur. This tends to show that the cartilage on the distal end of the femur must have been at least 4 cm. thick, and this is certainly not too much when we consider that the distal femoral cartilage of the macerated *Gallus* figured above had a thickness of 4·5 mm., while the femur itself measured 94 mm. in length. It becomes evident that just as we could never try to bring the macerated femur of *Gallus* into correct juxtaposition to the acetabulum without allowing for a great amount of cartilage, so we cannot base any conclusion as to the position or direction of the femur in *Stegosaurus* exclusively on the shape of its articular surface; and this must be emphasized all the more since such an attempt has recently been made by Tornier in regard to the similarly-shaped femur of *Diplodocus*. The reason why the discussion of the femoral cartilage caps of *Omosaurus* needs to be so detailed is, that Tornier has recently expressed the belief that the similarly-shaped femur of *Diplodocus* was only covered with a few millimetres of cartilage.

Even by those who hold the contrary view the amount of cartilage in *Diplodocus* is thought to be correlated with the aquatic habits of this monster, but this theory cannot apply to the heavily armoured Stegosaurs. I quite believe that the feeble ossification of the sternal apparatus and the low degree of ossification of the distal carpals and tarsals in *most* Dinosaurs are much more likely to explain the great cartilage caps on the femora of the Stegosauridæ and similar animals than the hypothetical aquatic habits. These features and the coarse structure of the bones indicate a low degree of ossification in the whole body, and the great masses of cartilage were probably needed to ensure the continuous increase of size throughout life. Perhaps this was one of the causes for the rapid extinction of the Sauropoda.

Besides the development of the so-called articular surfaces, the feeble development of the fourth trochanter is an interesting feature in the femur of our new *Stegosaurus*. According to Marsh's description the femur of the American *Stegosaurus* shows no marked fourth trochanter, while *St. durobrivensis* bears this process. The femur of the type-specimen of *O. armatus* is too badly crushed to show this feature; on *O. vetustus*, according to F. von Huene, there is no such process. *O. Lennieri* shows a rounded but marked swelling with a rugose surface that can well be called a distinct fourth trochanter, and *St. priscus* bears on the interior posterior surface, rather high up on the shaft of the bone, an obtuse swelling, which dies out very rapidly both upwards and downwards, and must be considered as the last trace of this trochanter. It may be concluded that the variable development of the fourth trochanter affords a good character for distinguishing the different species of Omosaurs and Stegosaurs.

The tibia and fibula (Fig. 7) are represented by more than half of each bone in *St. priscus*. Like in the Ceratopsidæ and *St. ungulatus*, the strong tibia is distally enlarged and flattened on the antero-exterior border for the reception of the fibula. Both bones are so closely applied against each other and to the fused calcaneum and astragalus that this part of the foot formed one inflexible piece.

Although the tibia is imperfect at its proximal end its length can be estimated at 57–60 cm.

Since, as already mentioned, the femur of *St. priscus* measures 90 cm. in length, the ratio of these two bones in this species is 2 : 3, while according to Marsh's figures it is something like 7 : 4 in *St. ungulatus*.

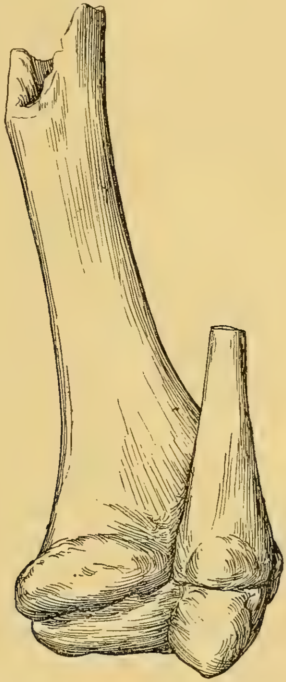


FIG. 7. Anterior view of tibia and fibula of *St. priscus*.

The ratio between humerus and femur is: 1 : 2·3 in *St. ungulatus*; 5 : 9 in *St. priscus*; 4 : 5 in *O. armatus*. Thus, in the length of the limb-bones *St. priscus* is intermediate between the two other forms.

Pelvis.—With the help of Mr. D. M. S. Watson, of Manchester, three most unpromising pieces of bone have been made out to represent pieces of the ilia. The left post-acetabular process and portions of the margins of both ilia just near the acetabulum are present. Though not very characteristic and rather crushed, the post-acetabular process agrees in its slender shape rather with *O. Lennieri* and *armatus* than with *Stegosaurus*, but the absence of the rest of the ilium is to be regretted all the more, since this bone is the most characteristic for separating the genera *Omosaurus* and *Stegosaurus*.

The slender pubis of *St. priscus* (Fig. 8*a*) is a very remarkable element. Its anterior branch, corresponding functionally, though not in its origin, to the processus pectinealis of birds, and therefore appropriately named processus pseudopectinealis, is badly fractured; but from the part preserved we may infer that it had a long, slender, blade-like shape, as in *O. armatus* (Fig. 8*a*), but was more inclined downwards than in this genus. The foramen obturatorium is open towards the suture of the ischium, as in *St. ungulatus* and *Omosaurus.* The acetabulum is but feebly marked and disfigured by crushing; the post-acetabular part of the pubis is a slender rod-like bone, of which the middle part is wanting. The distal end of the pubis is thickened and covered with rugosities, which form, where the pubis originally met the ischium, a horseshoe-shaped area. This area and a strong

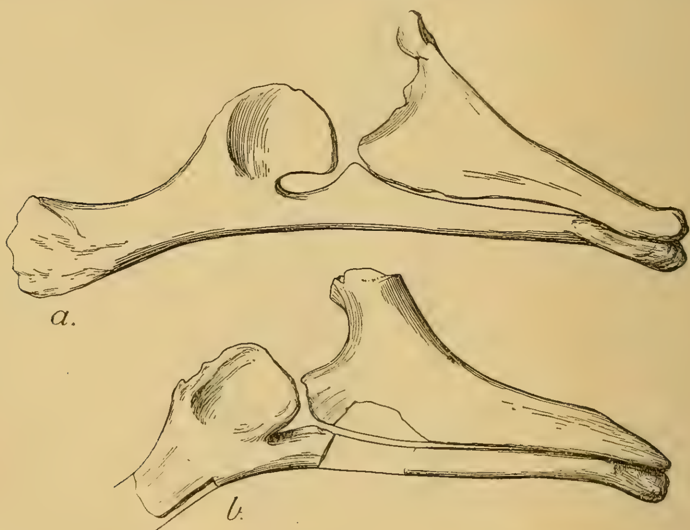


FIG. 8. *a.* Ischium and pubis of *O. armatus.* *b.* The same of *St. priscus.*

projecting rugosity on the inferior surface of the shaft of the pubis were both well figured by F. von Huene in the *Centralblatt für Mineralogie,* etc. (1902), when discussing the Cambridge specimen of *St. priscus.*

In consequence of its slender rod-like shape, the pubis of *St. priscus* resembles the same bone in *O. armatus* more than in *Stegosaurus,* but the rugosity on the shaft is wanting in *O. armatus.* A slender rod-like post-pubis is present also in *O. Lennieri.* Some evidence that the pubis of *St. priscus* was more slender than the same bone in *O. armatus* is afforded by the shape of the well-preserved ischium. This bone (Fig. 8*b*) is a long, triangular, flat element, showing a concave surface only at the acetabulum and tapering in the usual *Omosaurus*-like manner towards its distal end, which is triangular in section and is applied closely to the pubis. Further forwards a longitudinal cleft occurs between these two bones. Compared with the ischium of *O. armatus* (Fig. 8*a*) it may be seen that the distal half, though it has on its upper margin the notch characteristic of *Stegosaurus*, is much more slender in *St. priscus*, but the flat, desk-like shape is the same in both animals. If we compare this type of ischium with the same bone in *St. ungulatus* or *O. Lennieri* we find a fundamental difference, for in these two genera the ischium is not flat but twisted, and the superior margin of the ischium curves in such a manner as to meet in the median line at the proximal part of the rather long ischiadic symphysis, so that a great part of the ischium is thus modified into a horizontal plate that overlies the pubis. I am at a loss how to explain this difference in two forms so closely allied, for it seems difficult to explain it simply through post-mortem pressure. The longitudinal cleft between the pubis and the ischium, which is present in both species of *Omosaurus* and our Stegosaurian, is a character found in all primitive Ornithopoda; the closing of this cleft observable in *St. ungulatus* must therefore be regarded as a mark of specialization.

To facilitate a comparison of the ischia of *O. armatus* and *St. priscus* it has been thought advisable to figure these bones of both species near each other, and this seems all the more necessary because the pelvis of *O. armatus* has never yet been figured in the proper position.

Dermal Armour.—Associated with the bones just described several badly crushed pieces of dermal armour were discovered. Both spines and plates are present.

The plates are somewhat asymmetrical. Towards their base they are rounded and equally rugose on the exterior and interior margin, thus proving that they rose nearly vertically out of the skin; since, however, they are all more or less in a fragmentary condition, it seems enough to publish only a diagram of the transverse section (Fig. 9*a*) to show how this kind of plate would be inserted in the tissue of the body.

Though as badly preserved as the plates, the two spines found among the material show such peculiar features as to justify a more detailed description. The fragments are nearly similar, and include in both cases the base of a spine and its attachment-surface. The height of the specimen figured is 29·5 cm., its breadth 10 cm., its thickness at the summit 2·5 cm.

Of the upper part probably three-fourths or more is missing, but the base is entire and scarcely deformed by crushing. The piece shows an anterior and a posterior ridge, a more concave outer and a flatter inner surface, the latter being divided into a superior and an inferior half. On the outer side (Fig. 9*b*) at the base only a narrow rugose margin is observable; on the inner side, however, the rugose area reaches much higher (Fig. 9*c*) and occupies nearly half of the fragment, making an obtuse angle with the upper half of the spine. The great extent of the rugosity on the inner surface and the flatness of the surface over which the rugosities extend prove that while the exterior part of the bone was only slightly embedded in soft tissue, the interior side continued to adhere to the skin up to a much higher point; hence we may conclude that this spine rose, as indicated in

Fig. 9*d*, very obliquely from the body, or else that the curve to which it was attached must have had at least a diameter of 80 cm., if not much more.

As the lack of rugosities and the small size of the later caudals show that the end of the tail of *St. priscus* was *not* covered by powerful muscles and can scarcely have attained a diameter of 40 cm., it is evident that these two particular spines of *St. priscus* cannot have been situated on the tip of the tail, but must have been on some other part of the body. Leaving the shape of the spines entirely out of consideration, and judging only from the evidence afforded by the other armoured European Dinosaurs, notably *Scelidosaurus* and also *Hylæosaurus* and *Polacanthus*, one would never be induced to place the dermal spines on the tail of our Stegosaurian, but on the scapular region. This determination is apparently supported by the shape of the actual surfaces of attachment of the bones in question.

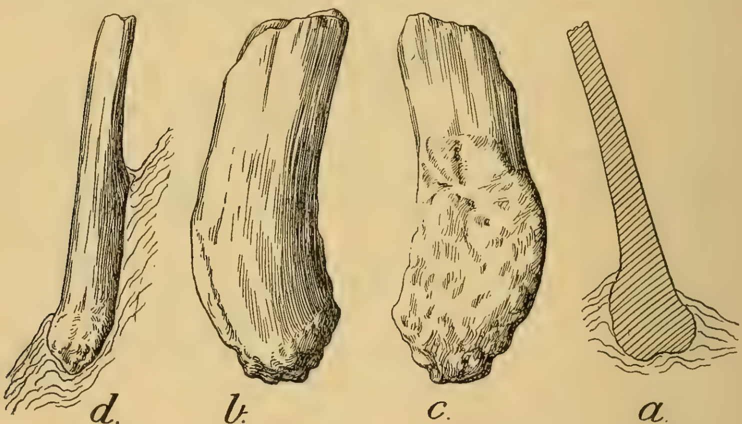
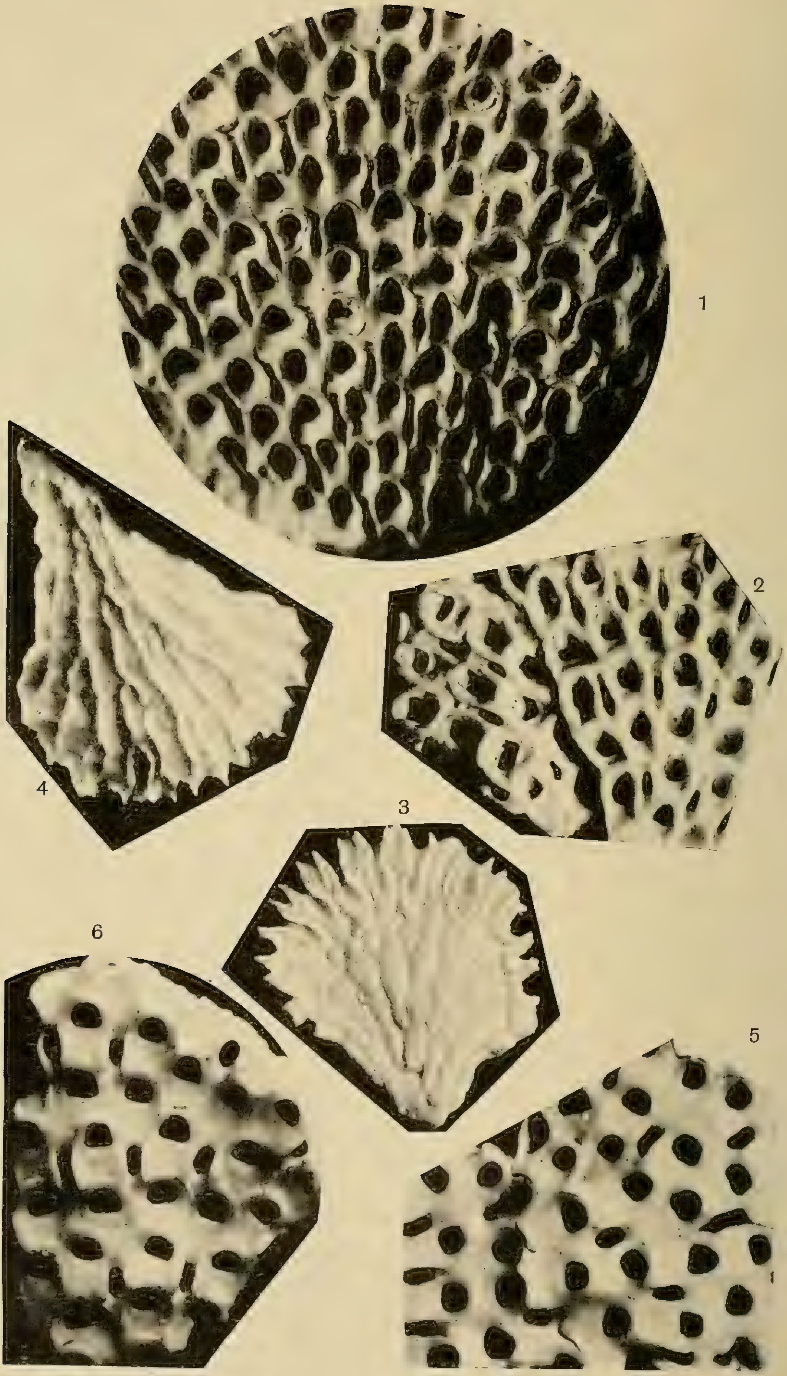


Fig. 9. *a*. Transverse section of dorsal dermal plate of *St. priscus*, with indication of hypothetical attachment to body-tissue. *b*. Exterior view of spine of the same animal. *c*. Interior view of the same piece. *d*. Marginal view of the same piece, with indication of hypothetical body-tissue.

Conclusion.—As already pointed out in the course of this paper, *St. priscus* agrees in the stage of evolution of its dorsal vertebræ somewhat with *St. ungulatus*, while in its limbs it holds an intermediate position between *O. armatus* and *St. ungulatus*. In its pelvis it corresponds with the genus *Stegosaurus*, though representing a new species.

Considering the development of the preacetabular part of the ilium as a generic character, we may arrange the members of the genera *Stegosaurus* and *Omosaurus* in the following manner:—

Genus Omosaurus (Owen). Ilium not very elongate anteriorly, widening backwards rapidly towards the acetabulum and the first sacral vertebra, its anterior extremity rounded. Neural arch of dorsal vertebræ slightly elevated. Five sacral ribs present. Sacrum much depressed from top to bottom.



R. M. Brydone, Photo. *Bemrose, Collo., Derby.*

NEW CHALK POLYZOA.

O. armatus (Owen). Dorsal vertebræ with lateral pits; sacral vertebræ not much abbreviated. Ratio between humerus and femur 4 : 5. Articular ends of femur not much expanded.

O. Lennieri (Nopcsa). Dorsal vertebræ without lateral pits; sacrals strongly abbreviated. Fourth trochanter feeble but well marked. Articular ends of femur not much expanded.

O. vetustus (Huene). Articular ends of femur moderately expanded, without fourth trochanter.

Genus STEGOSAURUS (Marsh). Ilium very elongate anteriorly, its breadth increasing only gradually backwards. Four sacral ribs present. No very great dorso-ventral compression of the sacrum. Articular ends of femur not expanded.

St. durobrivensis (Hulke). Femur with strong fourth trochanter.

St. priscus (Nopcsa). Neural arches of dorsal vertebræ moderately elevated. Femur with rudiment of fourth trochanter. Ratio of humerus to femur 5 : 9.

St. ungulatus (Marsh). Neural arches of dorsal vertebræ very much elevated; sacrals not much abbreviated. Femur without fourth trochanter. Ratio of humerus to femur 1 : 2·3.

II.—NOTES ON NEW OR IMPERFECTLY KNOWN CHALK POLYZOA.

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

(*Continued from Decade V, Vol. VII, p. 483, 1910.*)

(PLATES IX AND X.)

PAVOLUNULITES SCANDENS, sp. nov. Pl. IX, Figs. 1–4.

Zoarium free, unilaminate, the back divided by somewhat wavy, shallow, slightly diverging furrows into long narrow strips which correspond with the lines of zoœcia; these strips are occasionally crossed by very shallow depressions or furrows corresponding to the boundaries of individual zoœcia.

Zoœcia disposed in gently diverging and outward-curving lines, which are in some places confluent and in others separated by vibracularia; they are short and broad, with bulging sides, but very variable in size and outline, average length ·55–·6 mm., breadth (maximum) ·6 mm.; the back wall very soon leaves the back of the zoarium and rises gently but steadily up to the level of the front wall at the head of the zoœcium, and the succeeding zoœcium grows out from beneath it; in the shallow part of the back wall may sometimes be observed a pair of large foramina; the aperture is terminal and large, occupying the upper two-thirds of the area, irregular in size and shape, but varying round a type which is long, broad, and nearly rectangular, with rounded corners, rather wider at the foot than the head and with a slight inflexion of the sides; at the head the outline often becomes indistinct; a fairly typical length of aperture would be ·35–·4 mm., and breadth ·25–·27 mm.

Oœcia small, inconspicuous swellings at the head of the zoœcium;

one can be seen in the upper left-hand part of Pl. IX, Fig. 1, near the margin.

Vibracularia set very deep between the zoœcia, whose bulging sides as a rule overhang them sufficiently to hide part of the aperture, which is long and narrow, rounded above but tending to be pointed below; below the aperture the front wall usually rises quickly to a point between converging zoœcia; above the aperture the front wall usually rises very little and abuts at some depth against the succeeding zoœcium of one of the adjoining lines.

In general structure this species is closely related to the form described by Beissel as *P. costata*, D'Orb., but is easily distinguishable by the size and shape of the aperture and of the zoœcia generally. It seems to be confined to the upper part of the *M. cor-testudinarium* zone, where it is not uncommon on the Sussex coast and may reach a very considerable size, my largest specimen (a broken one) being 9·2 mm. by 15·5 mm.

Pavolunulites declivis, sp. nov. Pl. IX, Figs. 5 and 6.

Syn. *Pavolunulites costata*, Beissel, Bryozoen der Aachner Kreidebildung, p. 37, pl. iii, figs. 39–41.
Semieschara costata, Marsson, Bryozoen der Weissen Schreibkreide der Insel Rügen, p. 76.
Non *Pavolunulites costata*, D'Orbigny, Paléontologie Française, vol. v, p. 359, pl. 706, figs. 9–11.

A form of *Pavolunulites* closely allied to *P. scandens* occurs in the zone of *Act. quadratus* and at Trimingham. It is apparently identical with the form described and figured by Beissel as *P. costata*, D'Orb. (after comparison of his specimens with D'Orbigny's single "defective" type). This identification was accepted by Marsson, but with obvious misgivings, which seem justified. D'Orbigny's figure is not clear enough to give details accurately, and the only substantial character furnished by his description is the ribbed back, which is wholly different in type from that of the Aachen and English forms. The broad characters of the back are so constant among the Lunulitidæ that I cannot ignore this difference, and I therefore give Beissel's form a separate name. There is also no sign in Beissel's figures or description of the raised rim to the aperture mentioned by D'Orbigny. The English specimens agree very closely with Beissel's admirable figures. The species is clearly distinguished from *P. scandens* by the longer and narrower zoœcium with a sub-quadrate longitudinal section (due to the steep descent of the wall from the head of the zoœcium to the back wall, in consequence of which it is only faintly visible within the aperture), the broader and much shorter zoœcial aperture varying round a semicircular type and the shorter and broader vibracularian aperture. *P. elegans*, D'Orb. (loc. cit., p. 359, pl. 706, figs. 5–8), agrees very closely in the pattern of the back, but is readily distinguished by the pointed zoœcia. *P. elegans*, Beiss., appears to be a different species, so named by oversight, and may be known as *P. Aquensis*. I have not seen any definite oœcium.

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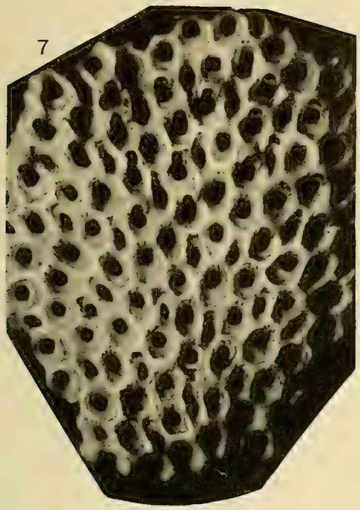

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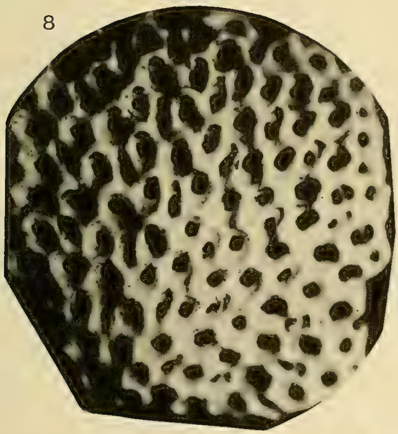

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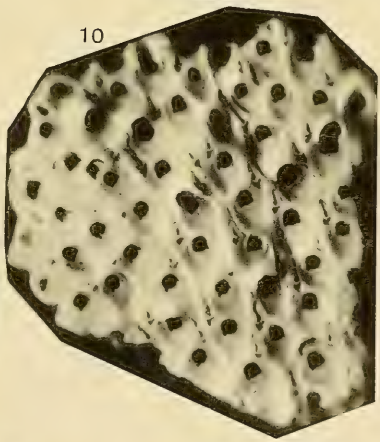

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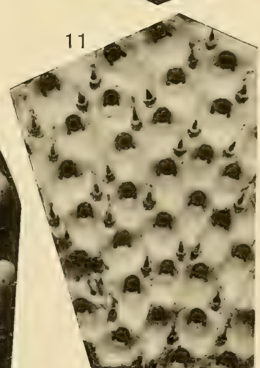


R. M. Brydone, Photo. *Bemrose, Collo., Derby.*

NEW CHALK POLYZOA.

It occurs very sparingly in the *Act. quadratus* zone of Hants and the Isle of Wight, and at Trimingham.

Pavolunulites subquadrata, sp. nov. Pl. X, Figs. 7–9.

Zoarium free, unilaminate; my specimens range from 3·4 mm. by 3·6 mm. up to 6·5 mm. by 8·1 mm., the back covered with numerous prominent flattened radiating ribs, many of which show a faint median furrow.

Zoœcia small, average length ·5–·55 mm., breadth ·35–·45 mm., arranged in slightly diverging rows; intercalated rows beginning with a vibracularium; aperture nearly terminal, rather longer than wide, and slightly wider below than above, corners rounded below and square above; two little nicks in the margin may often be seen at the head of the zoœcium.

Oœcia short and wide, only partially attached by the under side and with the free edge deeply cut back into a semicircle.

Vibracularia shallow, with a long narrow aperture tapering above to a rounded end, but below to a pointed end; above the aperture the front wall does not rise, but abuts at some depth against the succeeding zoœcium. They are sometimes vicarious.

Common in the upper part of the *M. cor-testudinarium* zone on the Sussex and Isle of Wight coasts, and I have also found it at the same horizon in Hants. I believe it to be confined to this zone.

A friend has pointed out that I have nowhere mentioned that my photographs are touched up before reproduction. This is a fact and I have found it inevitable, as the shortness of focus of the camera and the irregularity of surface of the fossils make it hopeless to expect photographs sharp enough to be really illustrative. To demonstrate this I have for this and the succeeding species given an exceptionally good photograph *au naturel* and a much inferior one touched up, and I do not think there can be any doubt which is which, or which is the more precise.

Lunulites Marssoni, nom. nov. Pl. X, Figs. 10–12.

Syn. *Semieschara crassa*, Beissel, op. cit., p. 42, pl. iv, figs. 47–50; Marsson, op. cit., p. 75.

Fragments of a form corresponding closely with Beissel's figures of *Semieschara crassa* are not uncommon at Trimingham. The only points in which they differ are that the posterior slit in the vibracularia has become a wide deep-set opening and that the aperture of the vibracularia has become more or less pointed anteriorly, points which do not appear to justify even varietal recognition. One or two of my larger fragments would strongly suggest that they are parts of a Lunulite, and fortunately I have obtained one practically perfect circular Lunulitine specimen, whose diameter is about 9·7 mm. No doubt the deep irregular depressions exemplified in Fig. 12 form lines of weakness along which large specimens break readily. Unfortunately there is already a *Lunulites crassa* (Tenison-Woods, Trans. Roy. Soc. S. Austr., iii, p. 5), and I have renamed the species after the second of the only two authors who refer to it, the name of the first not being available.

EXPLANATION OF PLATES IX AND X.

(All figures magnified 12 diams.)

PLATE IX.

FIG. 1. *Pavolunulites scandens*, sp. nov. Part of a good-sized specimen. Seaford.
,, 2. Ditto. A specimen which was easy to clean out and shows the foramina in the back wall. Seaford.
,, 3. Ditto. Back of a small specimen. Seaford.
,, 4. Ditto. Back of a larger specimen showing at one point traces of the marginal growth-outline not obliterated in the centre of the zoarium. Seaford.
,, 5. *Pavolunulites declivis*, sp. nov. Part of a large fragment. Trimingham.
,, 6. Ditto. A small fragment. Trimingham.

PLATE X.

FIG. 7. *Pavolunulites subquadrata*, sp. nov. Nearly the whole of a zoarium. Seaford.
,, 8. Ditto. A zoarium. Basing Park, Hants.
,, 9. Ditto. Back of a zoarium. Seaford.
,, 10. *Lunulites Marssoni*, nom. nov. A fragment. Trimingham.
,, 11. Ditto. Part of another fragment. Trimingham.
,, 12. Ditto. Back of another fragment. Trimingham.

III.—ON *PLEUROCARIS*, A NEW CRUSTACEAN FROM THE ENGLISH COAL-MEASURES.

By W. T. CALMAN, D.Sc.

THROUGH the kindness of Mr. Walter Egginton I have recently had an opportunity of studying an interesting series of Crustacea from the Coal-measures of Coseley, near Dudley. Most of the specimens can be referred, with more or less probability, to the division Syncarida, which includes the living *Anaspides* and its allies, and among them are some which I regard as representing a new genus. Although the fossils, which are contained in nodules of clay-ironstone, often show very minute details of structure in a beautifully perfect state, it is just those features most important from a morphological point of view that are most frequently obscured. There are many essential points that cannot be determined from the material at my disposal, and the conclusions drawn as to the systematic affinities of the genus must therefore be regarded as to some extent provisional.

Sub-class MALACOSTRACA.

Division SYNCARIDA (?).

PLEUROCARIS ANNULATUS, g. et sp. n.[1]

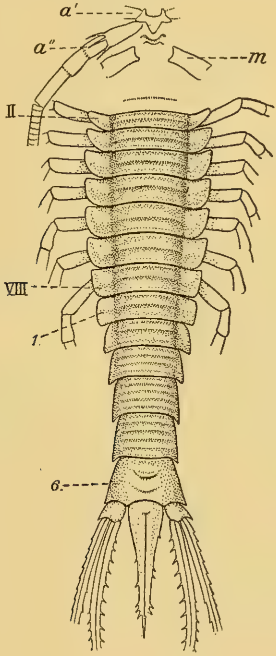
The body measures approximately 14 mm. in total length, and 2·9 mm. across the widest part. It is extended or only slightly curved ventrally, and the dorsal surface is exposed in all the specimens.

The *head* is obliterated in all the specimens seen, and only impressions of some of its appendages are preserved. What appear to be the basal segments of the *antennules* are seen in front, on either side of a small triangular median plate. Behind these is a stout *antenna* with a peduncle of three (?) segments and a portion of a flagellum showing

[1] For a diagnosis of the genus see p. 160.

indistinct traces of many small segments; a group of three or more large spines is placed, apparently, at the distal end of the first visible segment of the peduncle. A pair of large impressions a little way behind the antenna represent, in all probability, the *mandibles*.

The *thoracic region* consists of seven free somites, although the first (the second of the complete series of eight) is not perfect in any of the specimens. Each somite is roughly semicircular in transverse section, and has a pair of horizontally expanded *pleural plates* overhanging the attachment of the limbs. The antero-posterior length of the somites increases from the first to the fourth or fifth, and the



Pleurocaris annulatus. Partial restoration of the dorsal surface. × 6. Based chiefly on specimens Nos. 18 and 23 in Mr. Egginton's collection. Drawn by Miss G. M. Woodward. *a'*. antennule (?); *a''*. antenna; *m*. mandible; II, second thoracic somite; VIII, eighth thoracic somite; 1, first abdominal somite; 6, sixth abdominal somite.

pleural plates, at first bluntly pointed and slightly produced forwards, become more square-cut on the posterior somites. The dorsal surface of the somites is marked with strong transverse ridges, giving the body an annulated appearance and making the limits of the somites hard to define. There appears to be one ridge about the middle of each somite, and two others, which only become prominent on the hinder somites, at the anterior and posterior margins respectively. The thoracic *legs*, of which seven pairs can be made out, are all similar and rather stout. No distinct traces of exopodites can be seen.

The *abdomen*, excluding the telson, is longer than the seven thoracic somites together. The six somites increase in length from before backwards, and the pleural plates, horizontal and square-cut like the posterior thoracic pleura on the first somite, become bent downwards and acutely pointed backwards on the posterior somites. The abdomen thus appears narrowed posteriorly, but the actual width of the somites is apparently not very different from that of the thorax (1·4 mm.) if the pleural plates be excluded. The dorsal surface is ridged or annulated like that of the thorax, the ridges increasing in number from about three on the first somite to about five on the fifth. The exact number of ridges, however, is difficult to make out, owing to crushing and to the obscure delimitation of the somites. The sixth somite has two short crescentic ridges with the ends turned forwards but not extending to the margins of the somite. The pleopods are not visible.

The *telson* is separated from the last somite by a distinct line of articulation, and is at least a little longer than the last three somites together, but the tip is not perfect in any of the specimens. At the base it is about half as wide as the last somite, and it tapers gradually to a slender spiniform point. The lateral margins are slightly concave, and carry some short spines or teeth, but the exact number and arrangement of these could not be determined, except for a group of about three on each side at the base of the apical spine. The dorsal surface has a strong median keel.

The *uropods* are longer, probably considerably longer, than the telson. Each has a short stout protopodite, produced externally into a sharp tooth. The rami are very slender, and each is strengthened by a longitudinal keel. The exopodite is nearly straight, and is serrated on the outer, and less conspicuously on the inner, margin. The endopodite is curved inwards, and has a row of strong, widely spaced spines or teeth on the inner edge, and similar but smaller teeth on the distal part of the outer edge.

Locality.—Coal-measures, Coseley, near Dudley.

TYPE-SPECIMEN, No. 23 in the collection of Mr. Walter Egginton. Other less perfect specimens from the same locality in the Geological Department of the British Museum (I 13813, I 13814) are among the paratypes.

As regards the AFFINITIES of the species here described, it is to be observed, in the first place, that the possession of a 'tail-fan', consisting of a pair of biramous appendages on either side of a median telson, shows at once that it belongs to the Malacostracous Crustacea and to the series Eumalacostraca. The absence of a carapace practically narrows the comparison, among the existing groups of Eumalacostraca, to the Isopoda and the Syncarida.

The expanded pleural plates of the thoracic region give *Pleurocaris* considerable resemblance to an Isopod, and it must be admitted as a possibility that they may indicate real affinity with that Order; but, on the other hand, there are some important features that tell against this view. In all recent Isopoda, with exception of the aberrant family Anthuridæ, the telson is coalesced with the last abdominal somite, and, as this is the case also with the Tanaidacea and with many of the Cumacea, we must suppose this coalescence to be a very ancient character of the Order. Another important feature is the abbreviation of the abdomen, which is shorter than the thoracic region in all Isopoda and Tanaidacea. If we may assume, from the evidence of the Tanaidacea, that the acquisition of these characters preceded the suppression of the carapace in the evolution of the Isopoda, then the free telson and elongated abdomen of *Pleurocaris* suggest that it belongs to another line of descent.

The only Crustacea with which, so far as I know, *Pleurocaris* can be closely compared, are the species of *Acanthotelson* from the Coal-measures of Illinois.[1] The similarity is especially close as regards the tail-fan, both genera having the telson long and tapering to a sharp point, and the rami of the uropods very slender and armed with marginal spines. *Acanthotelson*, however, has no thoracic pleural plates, and has the first of the seven thoracic legs stouter than the others, and armed with large spines. The somites also lack the transverse ridges so conspicuous in the species here described. These differences seem to justify the establishment of a new genus for the English species, but it can hardly be doubted that the two genera are very closely allied.

I have previously expressed the view [2] that *Acanthotelson* is closely related to *Uronectes* (*Gampsonyx*), *Prœanaspides*, and certain other fossil genera, which, with the living *Anaspides*, *Paranaspides*, and *Koonunga*, I have grouped together under the name Syncarida. To this view I still adhere, although I now agree with Mr. Stebbing [3] in thinking that less reliance is to be placed on Packard's restoration of *Acanthotelson* than on the original figures of Meek & Worthen. I cannot, however, agree with Mr. Stebbing that *Acanthotelson* has any but the most superficial resemblance to *Apseudes* or any other Tanaidacea. The possession of a distinct carapace coalesced with the first two thoracic somites is a universal and no doubt primitive character of that Order, while in *Acanthotelson* the second somite is certainly distinct and possibly the first also. Mr. Geoffrey Smith has suggested [4] that *Acanthotelson* may be a "generalized Amphipod", but I am unable to find any support for this view in the known characters of the fossil. *Acanthotelson* appears to agree with *Uronectes* and with *Prœanaspides* in the segmentation of the thorax, and it resembles the

[1] The genus *Acanthotelson* was established by Meek & Worthen in 1865 (Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 46) for two species, *A. stimpsoni* and *A. inæqualis*, which were more fully described and figured in the following year (Geol. Surv. Illinois, ii, p. 399). In 1868 (Amer. Jour. Sci. (2), xlvi, p. 27, and Geol. Surv. Illinois, iii, p. 549) the same authors added a new species, *A. eveni*, and withdrew *A. inæqualis* as founded on an imperfect specimen of *Palæocaris*, giving also a fuller description of *A. stimpsoni* and additional figures. Packard in 1886 (Mem. Nat. Acad. Sci. Washington, iii (2), mem. 15, p. 123) discussed the genus, for which he established the group Syncarida, and gave a restoration of *A. stimpsoni*.

[2] Trans. Roy. Soc. Edinburgh, xxxviii, pl. iv, p. 799, 1896; Ann. Mag. Nat. Hist. (7), xiii, p. 155, 1904; Lankester's *Treatise on Zoology*, pt. vii, fasc. 3, Crustacea, p. 167, 1909.

[3] Natural Science, xi, p. 252, 1897.

[4] Quart. Jour. Micr. Sci., liii, p. 500, 1909.

former of these genera in having one of the anterior thoracic legs enlarged and strongly spinose; it is said to differ in having no thoracic exopodites, but even if this should prove to be the case it would not outweigh the important points of resemblance.

A PROVISIONAL DIAGNOSIS of the genus *Pleurocaris* may be given as follows:—Eumalocostraca without a carapace, with at least seven of the thoracic somites distinct and provided with horizontally expanded pleural plates; with at least seven pairs of the thoracic appendages not greatly differing in size; with the abdomen longer than the thorax; with the telson and uropods forming a tail-fan, the former distinct from the last somite and tapering to a sharp point, the latter with long narrow rami. Probably belonging to the division Syncarida and closely allied to the genus *Acanthotelson*, Meek & Worthen.

It is perhaps deserving of mention that the transversely ridged body-somites of *Pleurocaris* give it a superficial resemblance to certain Myriopods (Diplopoda) occurring in the same strata, and one occasionally finds fragments, destitute of appendages, which can with difficulty be referred to one or the other.

IV.—ON THE STRUCTURE OF THE ROOF OF THE SKULL AND OF THE MANDIBLE OF *PELONEUSTES*, WITH SOME REMARKS ON THE PLESIOSAURIAN MANDIBLE GENERALLY.

By C. W. ANDREWS, D.Sc., F.R.S. (British Museum, Natural History).[1]

IN the course of the preparation of the second part of the *Catalogue of the Marine Reptiles of the Oxford Clay* in the Collection at the British Museum, it has been necessary to examine in detail the structure of the skull and mandible of the Pliosaurs, especially of *Peloneustes philarchus*, several excellent specimens of which are included in the Leeds Collection. In the course of this examination several peculiarities have been observed, which on the one hand tend to reconcile the conflicting views as to the structure of the skull roof that have been put forward, and on the other serve to correct the interpretation of the elements of the mandible given in the first part of the Catalogue.

In the Plesiosaurian skull one of the most difficult points to determine is the precise position of the suture between the parietals and frontals, and the relationship of those bones to the pineal foramen. In *Murænosaurus*, *Cryptocleidus*, and *Tricleidus* this suture runs across the front of the pineal foramen, the parietal overlapping the frontal in such a way that while the former may completely enclose the foramen on the outer surface of the skull (as in *Murænosaurus* and *Cryptocleidus*), the frontals extend back beneath the parietals, and form the anterior border of the opening on the cranial surface. In the type-specimen of *Tricleidus seeleyi*, in which the various elements are disarticulated from one another, it can be seen that the anterior part of the border of the pineal foramen is formed by the frontals alone. In *Peloneustes* the arrangement of these bones is very different. In this case the forward extension of the parietals over the frontals anterior to the

[1] Published by permission of the Trustees of the British Museum.

pineal opening is much greater than the Elasmosaurs, and indeed is carried to such a degree that their anterior angle reaches the posterior ends of the facial processes of the premaxillæ, thus excluding the frontals from the middle line on the outer surface of the skull. On the cranial face (Fig 1) it can be seen that the parietals meet in front of the pineal foramen (*p.f.*) and run forwards in the form of a wedge (*par.*) between the frontals, which, though excluded from the pineal foramen, run back as far as about the middle of that opening. In front of the ventral wedge-like prolongation of the parietals the frontals (*fr.*) appear to meet at least for a short distance in the middle line beneath them. The posterior region of the frontal unites extensively with the post-frontal (*po.f.*), which extends back to the

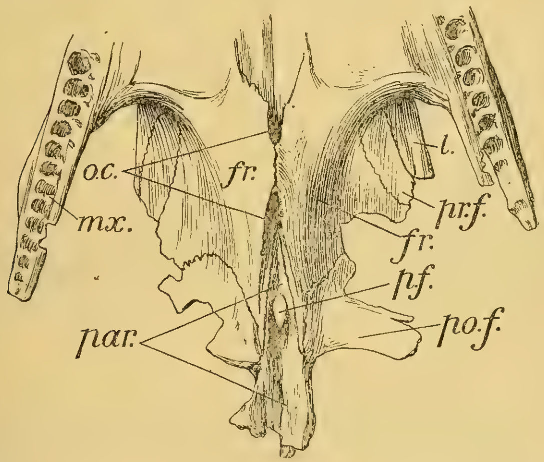


FIG. 1. Inner face of the middle portion of the skull roof of *Peloneustes philarchus.* (About one-third nat. size.) *fr.* frontals; *l.* lachrymal; *mx.* maxilla; *o.c.* channel enclosed by the downgrowths of the frontals; *par.* parietals; *p.f.* pineal foramen; *po.f.* post-frontal; *pr.f.* pre-frontal.

level of the middle of the pineal foramen, and has a short contact with the parietal; externally the post-frontal unites with the post-orbital. In front of the post-frontals the ventral surface of each frontal is raised into a high cristiform ridge, which curves downwards and inwards towards the middle line, where it just meets its fellow of the opposite side for a short distance, thus enclosing a deep channel (*o.c.*), probably for the olfactory nerves. Anteriorly these ridges die away a little in front of the anterior angle of the orbit. Antero-laterally the frontal unites with the pre-frontal (*pr.f.*), and these again on their outer side join the element which is here regarded as the lachrymal (*l.*).

Professor Williston,[1] in his account of the structure of the skull in

[1] *North American Plesiosaurs*, pt. i (Field Columbian Museum, Geological Series, vol. ii, No. 2 (1903), pl. iv, fig. 1). Also Proc. U.S. Nat. Mus., vol. xxxii (1907), p. 478, pl. xxxvii.

Dolichorhynchops osborni and *Brachauchenius lucasi*, both from the Cretaceous beds of Texas, describes the parietals as separating the frontals, and extending between them to meet the posterior ends of the facial processes of the premaxillæ. Possibly in these cases also the overlap of the parietals may be mainly superficial, and the frontals actually extend back to the level of the parietal foramen, in front of which they may either meet in the middle line on the inner surface of the skull, or at least be separated by a small interval only. If this is the case the structure of the skull in these American Plesiosaurs would fall into line with that seen in the European forms.

The Leeds Collection contains some very complete specimens of the mandible of *Pliosaurus* and *Peloneustes*, and examination of these, particularly of some belonging to *Peloneustes philarchus*, shows firstly that the structure of this part of the skeleton differs considerably from that occurring in the Elasmosaurs, and secondly that the description of the Elasmosaurian mandible given in the first part of the *Catalogue of the Marine Reptiles of the Oxford Clay* is wrong in several particulars, and I take this opportunity of making the necessary corrections.

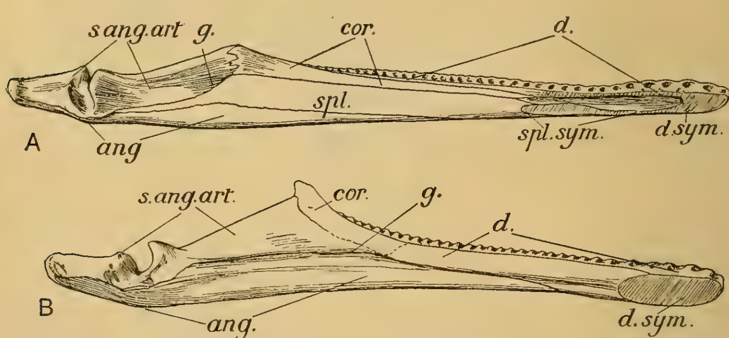


Fig. 2. Inner face of the left ramus of the mandible of (*A*) *Peloneustes philarchus* (about one-eighth nat. size) and (*B*) of *Murænosaurus* (a smaller specimen). *ang.* angular; *cor.* coronoid; *d.* dentary; *d.sym.* symphyses of dentaries; *g.* dental groove; *s.ang.art.* united surangular and articular; *spl.* splenial; *spl.sym.* symphyses of the splenials.

Each half of the mandible of *Peloneustes* is composed of five pieces. These are (1) the fused articular and surangular, (2) the angular, (3) the dentary, (4) the coronoid, (5) the splenial. Of these, as usual, the dentary (*d.*) is much the largest, extending from the coronoid angle to the anterior end of the jaw. It bears about forty teeth, of which about fourteen are in the symphysial region. The whole symphysial surface is formed by the dentary except a narrow ventral strip (*s.sym.*) formed by the extension forwards of the splenials. The anterior ends of the coronoids, though just extending into the symphysis, do not seem to have actually united with one another in the middle line. On the outer face of the jaw the posterior end of the dentary overlaps the surangular above and the upper part of the angular below the complex suture between them running downwards from the coronoid angle. The lower part of the angular is prolonged forward beneath the dentary, forming the ventral border of the jaw, to a point a little behind the symphysis. On its inner face the upper part of the dentary is covered to a large extent by the closely adherent coronoid, which extends from the coronoid angle, in the formation of which it shares, to just within the symphysis, though, as already noted, it is doubtful whether the coronoids themselves actually united with one another. The coronoid (*cor.*) is in turn itself overlapped on its inner face by the splenial (*spl.*), which roofs in the dental groove (*g.*) and unites by its ventral edge with the upper border of the angular, fitting into a deep groove in the upper border of that bone posteriorly and overlapping it anteriorly, where it runs down and forms the ventral border of the jaw. At its anterior end the splenial extends some distance in to the symphysis, uniting with its fellow in the middle line (*spl.sym.*). At its posterior end it forms the inner and lower edge of the opening of the dental canal (*g.*), and extends back as a narrow strip of bone along the upper edge of the angular to a point only a little in front of the articular surface for the quadrate. The surangular and articular (*s.ang.art.*) are represented by a single element: this forms the upper part and the rounded posterior end of the post-articular process: it also bears the articular surface for the quadrate, consisting of an outer and an inner concavity. In front of this the upper border rises towards the coronoid angle, and is broad and flattened. At the coronoid angle the bone is overlapped on its outer side by the posterior end of the dentary, and on the inner side at the same level it joins the coronoid; the lower edge is united with the angular throughout. The angular (*ang.*) forms the whole of the lower part of the posterior half of the mandible, and it sends forward a prolongation, overlapped externally by the dentary and internally by the splenial, to within a few centimetres of the symphysis. Its upper edge is deeply grooved and forms the floor of the dental canal, and receives the lower edge of the splenial at least in the posterior portion of that bone.

In a species of *Plesiosaurus* from the Uitenhage Beds of South Africa the general arrangement of the elements of the jaw are very similar, except that the coronoid is much shorter and does not reach the symphysis, and it is doubtful whether the splenial does so either. In the Liassic Plesiosauria also the structure, so far as can be made out, is similar: in the longer-snouted forms at least the splenial extends into the symphysis. In the jaws of the Elasmosaurs of the Oxford Clay the case is different, and it is necessary here to correct some errors in the account of the structure of the lower jaw in these reptiles, given in part i of the *Catalogue of the Marine Reptiles of the Oxford Clay*, examination of the Pliosaurian mandibles and other material having thrown new light on the subject. In the account there given the coronoid is said to be entirely wanting, while the splenial extended from the coronoid angle to the symphysis, closely adherent to the inner face of the dentary above the dental groove. As a matter of fact the coronoid (Fig. 2, *B*), though lost in nearly all cases, was present, and formed a prominent coronoid angle: at its posterior end it unites in suture with the surangular-articular, and extends forward for a short distance closely adherent to the inner face of the dentary: it is shown in text-fig. 48 of the Catalogue, where it is marked *spl.*; in the text-figure 46B it is nearly correctly shown, but is described as the coronoid process of the splenial. The splenial, so far as is known, is entirely wanting in the mandibles of *Murænosaurus* and *Cryptocleidus*, in which the dental groove remains open throughout its length. In a specimen of the mandible of *Tricleidus* (*R.*) there are traces of a very thin layer of bone crushed down into the groove; this may perhaps represent the remains of a very thin splenial element. Of course, in *Murænosaurus* and *Cryptocleidus* a similar structure may have been present and have been lost in the process of fossilization. The difficulty of determining the position of sutures in the more or less crushed mandibles which were examined must be the excuse for the error here corrected.

V.—The Neolithic Remains of Colonsay, in the Western Isles of Scotland.[1]

By W. B. Wright and the late Angus M. Peach.

I. Introduction.
II. Former Investigations in Colonsay.
III. The Colonsay Axe-heads.
IV. The Newly Discovered Neolithic Floor.
V. Description of the Flint Implements.
VI. Conclusions.

I. Introduction.

The more exact investigation of the distribution and mode of occurrence of Neolithic remains has received a much needed stimulus from the publication of Professor Brögger's memoir[2] dealing with the position of the strandlines in South-Eastern Norway during the stone age of that country. It has been clearly demonstrated in this important work that it is possible to distinguish, even in the relatively short-lived Neolithic culture, certain phases of chronological value, and to correlate these phases, by means of the distribution of the implements which characterize them, with the successive stages in the elevation of the land which affected Scandinavia in postglacial times. It has become clear, therefore, that the careful registration and description of Neolithic relics may lead to the most important scientific results, and it will be realized by all who indulge in archæological collecting that an exact determination of the locality of any find and of the relations it bears to the superficial deposits of the neighbourhood, more especially to the old shorelines which border the coasts of the British Isles, is of the utmost importance.

It must not be forgotten, however, that in Scandinavia conditions were peculiarly favourable for such investigations. The amplitude of

[1] Published by permission of the Director of the Geological Survey of Great Britain.

[2] W. C. Brögger, "Strandliniens Beliggenhed under Stenalderen i det Sydöstlige Norge": Norges Geol. Undersögelse, No. 41, 1905.

the *Littorina–Tapes* depression, amounting in the Kristiania region to about 70 metres, gave opportunities for the exposure of wide areas of land during recovery, and so facilitated correlation with the distribution of the implements. In the British Isles the corresponding depression, that of the so-called '25-foot beach', was relatively trifling in amount. The difficulty of employing the recession of the shoreline as a means of dating the implements is therefore enormously increased. Nevertheless it has been found possible to make certain advances in this direction. As early as 1869 Du Noyer[1] showed that in the north-east of Ireland the gravels of the '25-foot' raised beach, which has there an altitude of 18 or 20 feet above the present shoreline, abounded in flint implements. He pointed out that these implements were of a rather rude type, and contrasted them with the more perfect forms found on the surface in various localities, the latter including beautifully shaped arrow or javelin heads with barbs. He concluded that the men who made the first-mentioned ruder implements lived during the formation of the raised beach, while the more perfect types he regarded as being indicative of much greater skill and as being later in age.

Doubt having been cast on Du Noyer's statement that the implements were actually contained in the gravel of the raised beach, a committee of the Belfast Naturalists Field Club was appointed in the year 1886 to make excavations in the famous raised gravel spit in Larne Harbour, county Antrim, with the object of putting this point to the test. The final report[2] of this committee, drawn up by R. Ll. Praeger in 1889, proved that near the landward end of the spit the gravel contained implements to a depth of 19 feet from its surface, that is, throughout almost its entire thickness, a fine example of a rude axe-head being found at a depth of 11 feet from the surface. More recently Messrs. Coffey & Praeger[3] have carried out a more extended series of investigations into the Neolithic deposits of the North of Ireland, and have succeeded in establishing the important fact that the elevation of the land which brought the beach into its present position was almost entirely, if not quite, completed during Neolithic times. This has been effected by a determination of the levels of the Neolithic floors in the sand-dunes which overlie the raised beach gravels of Whitepark Bay on the north coast of Antrim and Port Stewart in Londonderry. It has also been proved by them in confirmation of Du Noyer's idea of an earlier and later stage of culture that the industry at these sites is quite distinct in character from that of the Larne beach and of a more advanced type. The nature of the flaking is somewhat different and polished axe-heads have been found in all the localities examined, whereas those obtained from the Larne gravels never show any attempt at polishing.

It is very remarkable that the rough-hewn axe-heads of the Larne

[1] G. V. Du Noyer, "On Flint Flakes from Carrickfergus and Larne": Q.J.G.S., vol. xxv, p. 48, 1869.

[2] Proc. Belfast Nat. Field Club (2), iii, pp. 198–210, 1890.

[3] George Coffey & R. Lloyd Praeger, "The Larne Raised Beach, a Contribution to the Neolithic History of the North of Ireland": Proc. Roy. Irish Acad., vol. xxv, section C, p. 146, 1904.

raised beach gravels, called by Messrs. Coffey & Praeger the 'Larne type', are identical, if we neglect the difference of material, which is determined by local circumstances, with the axe-heads of 'Nostvet type' which Professor Brögger finds to be associated with the highest shoreline of the *Littorina–Tapes* depression in Norway. We must remember, however, that as Messrs. Coffey & Praeger point out, the Larne Spit was not a dwelling-place, but only a workshop, where the axe-heads may possibly have been merely roughed out and taken away to be finished elsewhere.

In the Isle of Man Mr. Lamplugh found that the worked flints were plentiful on the surface of the inner portions of the wide gravel platform of the raised beach, which has there an altitude of 10 or 12 feet above high-water mark, while they were absent except as rolled fragments on the seaward portions. He concluded that at any rate part of the platform was in existence and above sea-level in Neolithic times, but that it may not have attained its full breadth until after the close of that period.[1]

Coming now to Scotland we find several cases like that described by Mr. Lamplugh. In the famous sands of Luce the Neolithic remains occur in the landward part of the sandhills overlying the gravels of the raised beach, while in the seaward part of the dunes they are absent.

Where the River Avon enters the carse lands of the Forth is a series of kitchen middens, described by Dr. Peach, all of which occur either on the bluff which borders the carse or just at its base, as if, when it was the limit of high water, the people who formed the middens, after searching the shores during low water, had retreated thither to enjoy their feast while the tide covered their hunting-ground.[2] In this case, however, there is no conclusive evidence that the middens were made by Neolithic man, since no implements have been found in them. The fact that they occur at the foot of the cliffs shows that they are at least later than the '25-foot' maximum submergence.

A few other cases in which Neolithic remains can be shown to have a definite relation to former oscillations might be cited, but the above are sufficient to show that very definite and valuable results may be obtained by careful observation of the distribution and site of implements. It is proposed in the following pages to give an account of a Neolithic floor recently found in one of the Western Isles of Scotland under conditions which seem to indicate a higher level of the sea during its occupation; and at the same time to pass in review for the purpose of comparison such other Neolithic remains as have hitherto been recorded from the island.

II. Former Investigations in Colonsay.

The first indication of the former occupation of Colonsay by Neolithic man was the finding in the bed of Loch Fada, at the time when its surface was lowered by draining, of a finely shaped stone

[1] G. W. Lamplugh, "The Geology of the Isle of Man": Mem. Geol. Survey U.K., 1903, p. 403.

[2] Mem. Geol. Survey Scot., Explanation of Sheet 31, Edin., 1879, p. 54.

axe-head. This discovery is mentioned by Mr. Murray in the appendix to *Summer in the Hebrides*, where he states that "both stone and bronze celts have been found by the shore of Loch Fada in Colonsay", and adds that these may be seen in the Museum of the Society of Antiquaries, Edinburgh, marked A.F. 173 and D.A. 43. To the discussion of the stone axe-head we will return later, and pass on now to give some account of the researches of Mr. Symington Grieve and the late William Galloway, the results of which were published in the Journal of the Linnean Society in the year 1883.[1] These investigators made an exploration of the shell-mound or kitchen midden of Caisteal-nan-Gillean in Oronsay. This mound was composed largely of blown sand, but contained a stratum of shells having a thickness of about 8 feet at the centre. From this were obtained bones of the red deer, marten, otter, rat, pig, grey seal, common seal, great auk, and guillemot, as well as the following traces of man :—

1. Two bone harpoon-heads, one with opposite and the other with alternate barbs.
2. A bone awl in a perfect state and the point of another.
3. A number of bones, partly of red deer, rubbed at one end so as to give an edge ; some of these were rubbed flat on both sides, others only on one.
4. Oblong water-worn stones of a slaty character, some with one end rubbed so as to form an edge.
5. A few oval and nearly round stones that showed marks of having been used for striking.
6. A few pieces of flint of small size and not obviously worked.
7. Some large flat stones with charcoal and burnt material around them, evidently hearthstones.
8. Some stone-heaters cracked by the action of fire.

Of these relics of human occupation only the water-worn stones (No. 4) call for further remark. They are merely elongated shingle stones picked up on the beach, and vary from 2 or 3 inches to quite a foot in length. The smaller ones, which were found near the hearths, bear marks of having been rubbed at one end, but the larger, which generally lay further out on the periphery of the mound, show, with the exception of being occasionally fractured at the ends, no trace of use. The employment among the islanders no very long time ago of similar stones as hammers for knocking limpets off the rocks suggested to Mr. Grieve a possible parallel use for those of the mound. Whether the smaller stones, which are rubbed down to an edge at one end, were employed for the same purpose as the larger ones, it is hard to say.

The deposits of the New Cave (Uamh Ur) on the south side of Kiloran Bay have also been studied by Mr. Grieve, but were found to be far less productive of objects of interest than the shell-mound of Caisteal-nan-Gillean. The strata, which only locally cover the shingle forming the floor of the cave, showed little variety throughout their thickness of 2 or 3 feet. The stalagmite was confined to the surface, and the deposit beneath consisted largely of charcoal and bones with layers of burnt clay and stones cracked by the heat. Remains of

[1] Symington Grieve, "Notice of the Discovery of Remains of the Great Auk or Garefowl (*Alca impennis*) on the Island of Oronsay, Argyllshire": Journ. Linn. Soc., Zoology, vol. xvi, p. 479, 1883.

a small variety of sheep and of the Celtic shorthorn (*Bos longifrons*) were abundant, and those of the horse were fairly common in the upper layers. In addition were found three bones of the pig and a single fragment of an antler of the red deer. The latter occurred in the base of the deposit. The only relic of human industry was the upper or eyehole end of a broken bone needle. The bones, however, showed traces of the presence of man, being split open and often calcined.

FIG. 1. Sketch-map of Colonsay and Oronsay on the scale of 3 miles to an inch, showing the positions in which the various Neolithic remains have been found.

From a comparison of this fauna with that of the Oronsay shell-mound Mr. Grieve draws the conclusion that the occupation of the cave was more recent than that of the mound. Thus the red deer, which is plentiful in the lower strata of the mound and persists throughout it, is represented only among the early deposits of the cave, and even there by a single fragment of an antler. The pig appears only in the lower deposits of the cave. The sheep, represented by one doubtful bone near the surface of the mound, occurs all through the cave deposits, while the ox first shows evidence of its presence about the middle of the latter. The horse is only found in the very uppermost deposits.

The chief interest attaching to these archæological researches is the proof they afford us that the earlier inhabitants, those of Caisteal-nan-Gillean, were a hunting and fishing folk, and that later, at the period of occupation of the cave, they had either been replaced by or had developed into a pastoral race, possessing at first only sheep, but, at a later period, cattle and horses as well. It will, however, be noted that none of the implements are of a type to yield definite evidence of date, and it cannot with confidence be claimed that these deposits are any proof of the occupation of Colonsay by Neolithic man.

III. The Colonsay Axe-heads.

The axe-head referred to on p. 167 was found at the western end of Loch Fada by Archibald M'Connell, who, on the day of the completion of the cutting made at Kiloran to lower the surface of the lake, is said to have been cutting thatch at its upper end. During the early part of the day this necessitated his wading almost up to his waist, but returning to his labours after dinner he found that during his absence the workmen at Kiloran had cut through the final barrier and the surface of the water had fallen several feet. The spot where he had been working in the morning was now dry and the thatch could be cut without wading. While walking on the soft peaty lake-bottom thus exposed he put his foot on something hard, and, stooping to see what it was, picked up the axe-head. It lay practically on the top of the peat in which are embedded the stumps of trees which occur in many places round Loch Fada, even at a depth of several feet beneath its present surface.[1]

The axe-head, which can be seen in the National Museum of Antiquities of Scotland, labelled A.F. 173, is of a whitish weathered rock, $6\frac{1}{2}$ inches long, $3\frac{1}{2}$ inches wide where widest, and $1\frac{9}{16}$ inches thick where thickest. It tapers to a point at the haft end, and has a surface which is ground smooth but does not at present exhibit any polish.

Unfortunately the conditions of this find do not afford much evidence as to its geological date. If we could be certain that it actually lay on the old forest soil, and if we knew for certain what trees grew in the forest, we might fix its date with regard to the immigration of the trees. We have, however, no reliable information on either of these points. All we can say is that it affords evidence that Colonsay was once inhabited by a race of Neolithic men, who had reached a stage of culture considerably higher than that of the Larne gravels or the kitchen middens of Scandinavia and Denmark.

The other axe-heads from Colonsay are also preserved in the National Museum of Antiquities of Scotland. One of these, No. A.F. 449, was found in a ploughed field in Uragaig, Colonsay, in 1881. It belonged to the Galloway Collection and was purchased in 1898. Its dimensions

[1] In connexion with this account of the circumstances of the find, however, it must be noted that even with an excessive estimate of the size of the outlet and of the rate of flow in it the surface of the lake could not have been lowered anything like 2 feet in less than twenty-four hours.

are $5\frac{7}{8} \times 2\frac{3}{4} \times 1\frac{3}{4}$ inches. It is of a similar type to the Loch Fada axe, being pointed at the haft end. It is, however, somewhat thicker and of a darker stone. The other, No. A.F. 497, is a much larger axe of greenstone weathered very white but blue on fresh fractures. Its dimensions are $11 \times 4\frac{3}{8} \times 2\frac{9}{16}$ inches. It was found at Reasagbuie, about 1 mile north-east of Scalasaig, and was presented in 1900 by the Rev. B. Mackenzie. It is much weathered, but the uneven surface presents a pitted appearance as if it had been picked all over. The pitting may, however, be merely an effect of the weathering. The haft end is pointed as in the other two axes, but the body is very cylindrical, and a further difference is apparent in the rapid divergence towards the cutting edge, which is thus wider than any other part of the axe. The form is very similar to that of an axe of much the same size from Shetland which is figured in the Museum catalogue (No. A.F. 226).

All these axes taper to a point at the haft end and belong clearly to Brögger's point-necked ('spidsnakket') type. The surface has been ground smooth, but does not at present exhibit any polish. They are certainly not of an early Neolithic type, and, if Brögger's classification has anything beyond a local value, ought to belong to his 'Newer Stone Age', which immediately preceded the Copper and Bronze Age.[1]

IV. The Newly Discovered Neolithic Floor.

Flint implements showing obvious Neolithic workmanship were first collected in Colonsay by the authors in the years 1907 and 1908. They occurred in abundance on a well-marked floor in the sand hills north-east of Balnahard in the north end of the island. This floor lies from 200 to 300 yards back from the present beach at a height of 22 to 24 feet above high-water mark of spring tides (see Fig. 2); and it is remarkable that, except in the immediate neighbourhood of the floor where they have been let down by wind erosion of the underlying sand, no implements occur at a lower level than this, or anywhere in the more recent sand-hills near the shore. This relation is suggestive of a higher sea-level at the time of the occupation of the floor. A single case of the kind, however, cannot be said to be anything more than suggestive, and we have not found any other accumulations of obvious Neolithic implements in the island.[2] The difference in level between the modern and '25-foot' shores has been estimated at about 23 feet, but may be as little as 21, or as much as 25 feet. It is just possible that the floor may correspond in date to the '25-foot' maximum depression, but on the whole it is more probable from its position that it is somewhat later. The sand which forms the substratum is indistinguishable from that of the rest of the sand-hills,

[1] W. C. Brögger, "Strandliniens Beliggenhed under Stenalderen i det Sydöstlige Norge": Norges Geologiske Undersögelse, No. 41; Kristiania, 1905.

[2] We have found a small scraper at about the same level in the Kiloran sand-hills and two worked fragments of flint on the surface of the '25-foot' beach in Port nan Fliuchan (Uragaig), as well as some rude chips on the links near Machrins. The latter are not obviously Neolithic, and none of the other cases are good enough to give much assistance.

but it would be difficult to say whether it is really blown sand or merely the upper portion of the old sandy shore.

The floor in which the implements lie is firmly cemented by oxide of iron, which pipes down into the subjacent sand in a remarkable way. The flint chips lie scattered about in all directions, and do not appear to be accumulated in one spot more than another. There was certainly no trace of anything in the nature of a mound, and no marked accumulation of shells or bones. We saw neither hearth-stones, nor heaters, nor any other indication of a fire having been lighted on the spot. In fact, it is exceedingly unlikely that the floor as at present exposed was in any sense a dwelling-place.

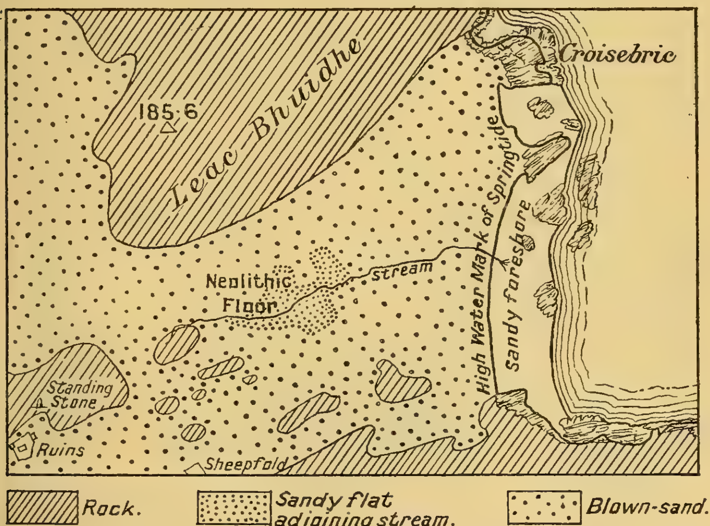


FIG. 2. Sketch-map of the Sand-hills at Balnahard on the scale of 6 inches to a mile, showing the position of the Neolithic floor.

The only objects of interest found on the floor in addition to the numerous flint flakes were some elongated water-worn shingle stones with rubbed or broken ends. These are merely fragments of the Torridon mudstones of the island, the cleavage in which frequently causes them to break up into elongated pieces, which become rounded on the shore. The ends of some of these stones are distinctly bevelled by rubbing, and others are broken in such a manner as to suggest that they have been used with considerable force. In the presence of these stones we have a suggestion, but only a suggestion, of contemporaneity with the shell-mound of Caisteal-nan-Gillean, where exactly similar implements have been found in considerable numbers[1] (see p. 167).

[1] Mr. T. C. Cantrill informs me that he has found a number of such elongated pebbles, averaging 6 inches in length, on flint chipping-floors in Pembrokeshire, and believes they are flaking-tools.

V. Description of the Flint Implements.

The flint implements found on the floor are on the whole rather rude, and few of them indicate any great skill in the manufacture. A large majority are merely flakes struck from a core and exhibit little or no secondary working. The cores themselves are not uncommon, but like the flakes are generally of small size. They frequently retain some portion of the original rounded and battered surfaces of the beach pebbles from which they have invariably been made. The material of these beach pebbles must have been rather intractable, having long lost any traces of quarry water, and the quantity available for selection was by no means large. Occasional flint pebbles can be found in the shingle beaches round the island, but they are certainly not at all common. The shore in the immediate neighbourhood is not composed of shingle, and the pebbles must therefore have been carried to this spot from other parts of the island. In describing the different types of implement found we will take them in order under the following heads :—

1. Cores and simple flakes.
2. Secondarily worked chisel-ended flakes.
3. Secondarily worked cutting-edged flakes or knives.
4. Notched flakes.
5. Pointed implements.
6. Scrapers.

Fig. 3. Small core, Neolithic floor in Sand-hills, Balnahard, Colonsay. Nat. size.

1. The predominant type of core is of conical form, the flaking having being effected from the base of the core towards the apex (see Fig. 3). The greater number of flakes thus produced are prismatic in form, but, when the fracture failed to run the full length of the core, pointed flakes were also produced. The majority of the flakes are triangular in section, narrow, and long, but broader flakes with a four-sided cross section are not uncommon (see Fig. 4, A), the latter being almost without exception the flakes which have been selected for further development by secondary working. The cores found had been reduced to a small size, as if there were a distinct demand for the minutest flakes.

2. Of the flakes showing secondary working the most simple types are those which have been chipped at one end with the evident intention of making a chisel-like tool. In all these the secondary chipping is at the bulb end of the flake and on the off side from the bulb, so that the latter forms, so to speak, part of the flat side of the chisel (see Fig. 5). The presence of the bulb on this flat side was

obviously a disadvantage, for in many cases attempts have been made to remove it, or at least reduce its convexity by striking small flakes off its apex (Fig. 5). It is hard to say why, in view of this disadvantage, the bulb end is constantly chosen for bevelling. This seems, however, to be a character of many of the flakes in the famous collections from the Culbin sands and Luce Bay in the Museum of the Society of Antiquaries. Attempts to remove the bulb are not, however, so marked in these cases. The explanation of the use of the bulb end may possibly lie in the knowledge that the worker possessed of the temper of the flint at that end, where he had already struck it. The Colonsay floor has yielded a considerable number of flakes with the bulb end re-worked, whereas we have succeeded in finding only a single flake with secondary chipping at the opposite end, and this one is actually worked at both ends.

3. Among the secondarily worked flints are several of rather varied shape which have their edges adapted for cutting or sawing.

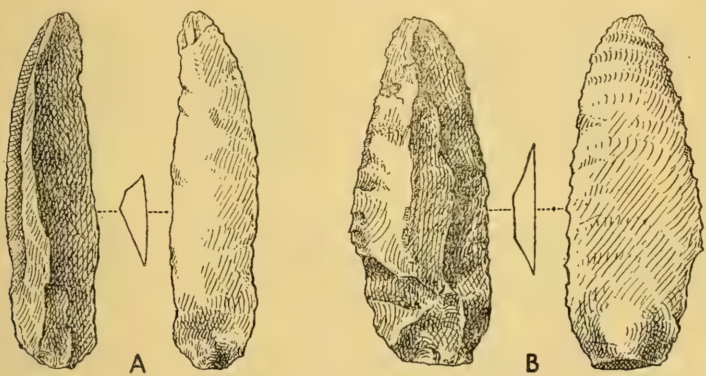


FIG. 4. Flint 'knives' from Neolithic floor in the Sand-hills at Balnahard, Colonsay. *A*. simple flake from core; *B*. flake with secondary working. Nat. size.

The flakes used for this purpose all have one side flat and formed of a single face of fracture, while the other is convex with several faces. The secondary flaking by which the saw edge has been obtained has all been done from the flat side towards the convex side, the result being a certain amount of bevelling similar to that of the chisel-shaped scrapers above described, but extending right along one or both edges of the flake. A good example is shown in Fig. 4, B.

4. Among the more uncommon types are a few notched flakes which had obviously a very special use, such, for instance, as scraping bowstrings. A natural nick in the flint has usually been taken advantage of and enlarged by secondary chipping, so as to produce a small crescentic bevel edge. The remaining edges of such a flake may also show secondary chipping, as if it had served as well for a saw or knife.

5. Apart from a number of flakes which possess a point as a consequence of the accidental intersection of faces produced when

they were struck from the core, a very few pointed implements were found. Only one obvious arrow-head (Fig. 6) has come to light, but this, if we take into consideration the intractable nature of the flint, shows a very fair amount of skill in the manufacture. Both sides of the flakes have been worked so as to produce a symmetrical edge, and the chipping is in places quite regular. One very perfect barb has been produced, but the other appears to have broken off in the making, a fact which probably accounts for the arrow-head having being left in the factory. A distinct tang had, however, been roughed out before the flake was abandoned.

6. Among the conical core-like flints referred to above are a few which are so low that the flakes struck from them cannot have been more than a quarter, or in some cases an eighth, of an inch in length. Such minute flakes may of course have been used for tipping arrows, but on the other hand they may merely have been removed with the object of fashioning the core itself into a bevel-edged scraper. There

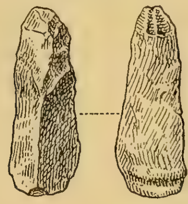


Fig. 5. Flake from core modified into chisel-shaped scraper by secondary working at the bulb end. Neolithic floor in Sand-hills, Balnahard, Colonsay. Nat. size.

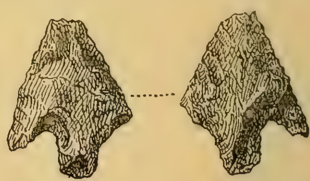


Fig. 6. Flint arrow-head from Neolithic floor in the Sand-hills at Balnahard, Colonsay. Nat. size.

are also in the collection several small more or less circular lenticular flakes with obvious secondary working, to which it is difficult to assign any other use than that of scrapers.

VI. Conclusions.

Unfortunately none of the flint implements described above are of sufficiently well-defined character to be referred with confidence to a definite phase of Neolithic culture. It is impossible even to say whether they are early or late Neolithic. Their roughness may be in part due to want of skill, but on the other hand it certainly is to some extent the result of the inferior nature of the material employed. Taking into account this latter factor the single arrow-head which has come to light cannot be regarded as ill-formed, though, of course, it will not bear comparison with the beautiful implements of Yorkshire and other districts where better material was obtainable.

The axe-heads found in various parts of Colonsay are more obviously of a late Neolithic type, but as regards their geological date we have not even such slight evidence as is forthcoming in the case of the flint implements. The other prehistoric remains of the islands have very little chronological value. Hoernes[1] draws a comparison between

[1] Moriz Hoernes, *Der Diluviale Mensch in Europa*; Brunswick, 1903.

the implements of the Oronsay shell-mound and those of the Asylien and Arisien of France. These names have been given by Piette to strata occurring in the cave of Mas d'Azil between deposits of the Reindeer Period and purely Neolithic deposits with polished axe-heads. The Asylien yields flat harpoon points of stag's horn to which those of Oronsay bear a considerable resemblance. In the overlying Arisien, and also in the still higher purely Neolithic strata, there occur pebbles and slabs of slate, which are polished to a cutting edge either at the end or at one side. These implements are regarded by Piette as foreshadowing the polished axe-heads of the Neolithic Period. The bevel-ended pebbles of Oronsay and of the Balnahard Neolithic floor in Colonsay certainly bear a resemblance to these, but, even when taken in association with the occurrence in Oronsay of the Asylien type of harpoon-head, they can hardly be regarded as sufficient evidence of an early stage of Neolithic culture in the islands.

Finally, the evidence of the connexion of the Neolithic floor of Balnahard with a higher level of the sea is of a negative kind, and could not stand by itself. Were it not that a similar relation is observable in other parts of Scotland and Ireland, no special significance could be attached to it.

NOTICES OF MEMOIRS.

The Jurassic Flora of Sutherland.

UNDER this title Professor A. C. Seward has given a general account of Scottish Jurassic plants, most of which have been obtained from Sutherland, and a particular account of the flora of the Upper Oolites of that county, based on materials collected by the late R. Marcus Gunn, F.R.C.S. (Trans. Roy. Soc. Edin., vol. xlvii, pt. iv, 1911). The formations from which plants have been obtained in Sutherland are: (1) Lower Oolites, including the Brora Coal Series of Great Oolite age, and possibly beds of Inferior Oolite, as suggested by Miss Stopes; (2) the Corallian Sandstone of Clyneleish Quarry, Brora, which has yielded in abundance casts of Cycadean stems described by Mr. Carruthers under the names of *Bucklandia* and *Yatesia*, but placed under the former genus by Professor Seward; (3) the Upper Oolites, between Kintradwell, north of Brora, and Helmsdale, Navidale, etc. The specimens in the collection of Mr. Gunn were obtained by him almost wholly from this last series, and mainly from Culgower Bay, in beds of Kimeridgian age.

The new forms described by Professor Seward are as follows:—

PTERIDOPHYTA.

FILICINEÆ.

Hausmannia Richteri.
Gleichenites Boodlei.
Marattiopsis Boweri.
Rhizomopteris Gunni.
Sphenopteris onychiopsoides.

GYMNOSPERMÆ.

GINKGOALES?

Phœnicopsis Gunni.

CONIFERALES.

Araucarites Milleri.
Masculostrobus Zeilleri, gen. et sp. nov.
Taxites Jeffreyi.

CYCADOPHYTA.

Pseudoctenis crassinervis, gen. et sp. nov.

These and other species are figured in ten plates and fourteen text-illustrations.

In his conclusion Professor Seward remarks: "It is generally agreed that the differences between Wealden floras and those from different horizons in the Jurassic system are comparatively small. It may be said without exaggeration that from the Rhætic and Liassic periods to the end of the Jurassic period, including the Wealden, the vegetation of Europe experienced no very striking or fundamental change . . . The Culgower flora has many features in common with the Upper Jurassic (Wealden) flora of Spitzbergen, the Wealden of England, Germany, and other regions, as also with the older Jurassic flora of East Yorkshire, which may be taken as a type of Middle Jurassic floras in various parts of the world. As one would expect in a flora of Kimeridgian age, we find an admixture of Wealden or Upper Jurassic, Middle, and Lower Jurassic species."

REVIEWS.

I.—A Monograph of the Terrestrial Carboniferous Arachnida of Great Britain. By R. I. Pocock. Palæontographical Society, in volume for 1910. 4to; pp. 84, 3 plates, and 42 text-figures. London, 1911.

IT is a matter of common complaint among zoologists that fossil animals, especially Invertebrates, are too often described by writers who have an insufficient knowledge of recent animals and of the literature referring to them. It cannot be denied that there is sometimes ground for this complaint, but, on the other hand, it must be admitted that there is justice in the palæontologists' reply that those who possess the necessary knowledge of recent animals can rarely be persuaded to take up the difficult study of their fossil remains. It is to be noted, further, that the scientific study of any group of fossils demands not only the broad outlook of the morphologist, but also the minutely detailed knowledge of the systematic specialist, since the necessary imperfections of fossil remains often leave only the most trivial and superficial characters from which to draw conclusions as to affinity; and it is just the systematic specialist who is least often ready to appreciate the scientific importance of palæontological research.

Mr. Pocock is recognized as one of the foremost authorities on recent Arachnida, and he has already made several noteworthy contributions to our knowledge of some of the fossil representatives of the group. Of the Monograph under review it is no exaggeration to say that it places the study of the Carboniferous Arachnida on a new footing, and it merits the attention of palæontologists and zoologists alike.

In all, thirty-three species are described, but, as the author very justly remarks, the species themselves are of very little importance in the present state of our knowledge, and more attention is given to discussing the characters and affinities of the Orders, families, and genera to which they are referred. A large proportion belong to the

Anthracomarti, an extinct group formerly included in the Opiliones, but regarded by Pocock as a distinct Order. The Phalangiotarbi are also given ordinal rank, and a new Order, Haptopoda, is established for a species to which the name *Plesiosiro Madeleyi* is given. It is pointed out that these three Orders may possibly "serve to bridge, to a certain extent, the interval between the Opiliones and the more primitive Orders of Arachnida".

The other Orders represented in the Carboniferous fauna are the Scorpiones, Pedipalpi, Araneæ, Ricinulei, and perhaps also Opiliones. So far as the evidence of the fossils goes, the members of these Orders seem to have resembled, to a remarkable degree, those existing at the present day, and they serve to illustrate once more the extreme antiquity of living types of invertebrate animals. A few of the forms, however, show characters of great morphological interest, the most striking being those presented by a scorpion to which the name *Eobuthus Holti* is given. In addition to some peculiarities, of which the significance is not quite clear, in the region of the genital somite, this scorpion differs from nearly all those hitherto known in having the ventral plates of the fourth, fifth, and sixth somites of the abdomen each with the hinder margin divided into two semicircular lobes overlapping the succeeding somite. As Mr. Pocock points out, these bilobed overlapping plates have "a general resemblance to the gill-bearing appendages of the same segments in *Limulus*", and, as he was unable to find any trace of stigmata upon them, he concludes "that the respiratory lamellæ lay beneath them as they do in *Limulus*". He remarks that "in possessing these lobate sternal plates the Scorpion now described is more like *Limulus* than is the Silurian Scorpion *Palæophonus*". It is quite possible, however, as Mr. Pocock himself suggested in describing the Scottish Silurian Scorpion some years ago, that the supposed mesosomatic 'sternites' of *Palæophonus* are really broadly laminate gill-bearing appendages, as they have been shown to be in *Eurypterus*. If this should prove to be so it would reduce the difference in this respect between *Eobuthus* and *Palæophonus* to the fact that in the former the appendages are lobate as in *Limulus*, while in the latter they are square-cut as in *Eurypterus*. At all events there can be no question as to the extreme interest and importance of *Eobuthus* from this point of view, and it is to be hoped that collectors will be induced to keep a look out for more perfect specimens which will throw further light on its structure.

W. T. C.

II.—The Zones of the Chalk in Hants. By C. Griffith, M.A., F.G.S., and R. M. Brydone, B.A., F.G.S. 8vo; pp. 36, with 4 plates. Dulau & Co., 37 Soho Square, London, W., 1911. Price 2*s.*

FOR more than twenty years Mr. Brydone has been studying the Chalk of Hampshire and its fossils, at first while a pupil at Winchester College under the guidance of Mr. Griffith, and afterwards in collaboration with him. The present work, while embodying the results of their joint labours, has been drawn up by Mr. Brydone.

We have also before us the neat little booklet prepared in 1891 by Mr. Griffith for the Winchester College Natural History Society, and a comparison between the lists of fossils then published and those in the pamphlet just issued shows how much has since been accomplished. For example, the number of Sponges recorded has been increased from 6 to 20, and of Echinoderms from 39 to 52; while among Cephalopoda, the species of Ammonites (still happily recorded under that generic name) have been increased from 5 to 13—the *Ammonites Bravaisianus*, d'Orb., of the older list being now recorded as *A. Neptuni*, Gein., as notified in Mr. Jukes-Browne's *Cretaceous Rocks of Britain*, vol. iii, p. 469.

A very great deal of additional information is now given with regard to the Chalk zones, and especially to the sub-zones of the *Actinocamax quadratus* zone, "which are capable of being separated all through the county." The following are the palæontological divisions adopted:—

Belemnitella mucronata.
Actinocamax quadratus, sub-zones—
  Actinocamax quadratus.
  Offaster pilula.
  Echinocorys scutatus, var. *depressus.*
Marsupites testudinarius.
Micraster cor-anguinum, with *Uintacrinus*-band at top.
M. cor-testudinarium.
Holaster planus.
Terebratulina 'gracilis'.
Inoceramus labiatus and *Rhynchonella Cuvieri.*
Actinocamax plenus.
Holaster subglobosus.
Ammonites varians and *Rhynchonella Martini.*
Plocoscyphia labrosa and *Stauronema Carteri.*

The authors have endeavoured to visit every chalk-pit in Hampshire, and they have zonal records of about 180 sections. Mr. Brydone hopes shortly to publish a zonal map of the county. In the full list of fossils now printed references are given to the particular pits or other exposures where the zones have been identified.

In Appendices the authors contribute definitions and figures of the several forms of *Bourgueticrinus* found in the Hampshire Chalk, and known under the specific names of *B. ellipticus* and *B. æqualis*. They likewise describe and figure some varieties of *Echinocorys scutatus*. The illustrative plates are excellent. Dr. F. L. Kitchin also describes *Thecidea Brydonei*, a new species from the zone of *Belemnitella mucronata*. This is figured in the text.

III.—Physical Geography for Schools. By Bernard Smith, M.A., F.G.S. pp. viii, 190, with 222 illustrations. London: Adam and Charles Black, 1910. Price 3*s*. 6*d*.

THIS work may be described as a concentrated essence of Physical Geography. Parts i and ii contain brief but concise accounts of the Solar System, the earth, its seasons, tides, and main features, of the atmosphere, climate, and geographical distribution of plants and animals on land and in water. The larger portion of the work, nearly four-fifths of it, is given up to the composition, structure, and erosion of the land, and the origin of the physical features: subjects appropriately dealt with by one who has gathered knowledge abroad, as well as in this country where he has been actively engaged for some years on the Geological Survey.

As examples of the illustrations we may mention Turf-cutting in Donegal; Anticline in Coal-measures, Saundersfoot, Pembrokeshire;

Earth Pillars in the Tyrol; High Force, Teesdale; Over-deepened Valley due to Glaciation, Ross-shire; Trent Bore at Gainsborough; and the Great Barrier Reef, East Australia.

The variety of topics which had to be treated in a limited space has tended to render too meagre some of the explanations and definitions, as in the case of dry Chalk valleys (p. 100), while a little more might have been said in description of such features as tundras and steppes. With reference to the latter the picture of the Kirghiz Encampment recalls to mind some of the desolate habitations in the Hebrides. In the definitions of shingle and gravel (p. 35) we should have indicated the more pebbly nature of the former, compared with the mixed and subangular character of the latter. The size of the stones is not usually regarded as a distinction, when we bear in mind some of the glacial 'cannon-shot' gravels. These, however, are trifling criticisms. The author has given so much information admirably expressed and illustrated, that not only students and teachers, but general readers who take interest in scenery will be glad to learn about the modes of sculpture of mountain, hill, and valley, of the varied origin of lakes, the development of rivers, the circulation of water underground, the formation of soils, and the many other subjects explained and discussed in this attractive volume.

IV.—Brief Notices.

1. London Springs and Spas.—In a work entitled *Springs, Streams, and Spas of London: History and Associations*, by Alfred Stanley Foord, 1910, the author has given a full and interesting account of the courses of the old (now buried) rivers and of the various noteworthy springs that supplied ordinary shallow wells and pumps, holy wells, and spas or mineral-water establishments. The conduit system of water-supply is described, and a few particulars are given of artesian wells. There are analyses of some mineral waters, and illustrations of Islington, Beulah, Streatham, and other spas, also of conduit-houses and old pumps. The geological features in connexion with springs and wells likewise receive attention.

2. The Glacial Geology of Norfolk and Suffolk is the title of a small work by Mr. F. W. Harmer (Jarrold and Sons, 1911, price 1*s.* net). The essay, which has been reprinted from the Transactions of the Norfolk and Norwich Naturalists' Society (vol. ix, pt. i, 1910), comprises an account of the North Sea Drift (Cromer Till and Contorted Drift) and of the Great Eastern Glacier that led to the formation of the Chalky Boulder-clay. The various Glacial Sands and Gravels are likewise described, and remarks are made on the origin of the valleys of Central Norfolk. The work contains, in fact, an interesting account, without tedious detail, of the Glacial period as it affected Norfolk; and it is illustrated by a contour map showing the distribution of the Drift and several pictorial views.

3. An account of Experiments with 'Water-finders' has been contributed by Professor J. Wertheimer to the Journal of the Royal Society of Arts (vol. lix, February 24, 1911). Experiments were made to ascertain the position of a well in the kitchen of Brislington

Hall. In this case the indications given by three experienced 'dowsers' were "absolutely at variance with one another", and the actual site of the well was not ascertained. We hardly think the test was a good one, because the well has a constant supply of water, and it is not improbable that the underground water extends beneath the whole area. Other experiments were made in different localities; in one case in reference to a drain, with an abundant flow of water, a few feet from the surface; in another case above a 3 inch water-main, the water being turned on and off at irregular intervals. The results showed that no dependence could be placed on the indications of the divining-rod. Again, experiments made to find gold and silver coins placed beneath saucers and cushions showed conflicting results.

4. The Fossil Horse of Bishop's Stortford forms the subject of a short article by Mr. E. T. Newton (*Essex Naturalist*, vol. xvi, p. 132, February, 1911). Attention was drawn in 1909 by the Rev. Dr. A. Irving to the discovery of the entire skeleton of a horse at a depth of 2½ feet from the surface at Bishop's Stortford. Dr. Irving was disposed to regard the remains as of Neolithic or Bronze Age, and Professor J. C. Ewart drew attention to resemblances between the Bishop's Stortford horse and examples from Walthamstow, believed to be of about the same approximate age. The horse of Bishop's Stortford, however, was larger, and Mr. Newton observes that the bones "present no characters which would indicate their being of prehistoric age; on the contrary, their agreement with the bones of modern horses points rather to a much more modern origin".

5. Western Australia.—Bulletin No. 36 (1910), issued by the Geological Survey of that country, contains an interesting series of "Palæontological Contributions". Dr. G. J. Hinde describes the Fossil Sponge Spicules in a rock from Princess Royal Township, Norseman District. The specimen, a soft white siliceous rock, was found to consist almost entirely of the spicular remains of siliceous sponges, with no traces of other organisms. In age it is probably newer than Cretaceous. Dr. Hinde remarks that "Besides spicules which resemble those of existing sponges, there are many in the deposit closely similar to detached spicules in material dredged from a depth of 3,000 fathoms off the south-west coast of Australia, and also to the spicules in the fossil sponge deposit at Oamaru, New Zealand, which is considered to be Upper Eocene in age". Other spicules belong to species found in European Cretaceous rocks. The rock was probably formed in the open ocean and at a considerable depth.

Mr. E. A. Newell Arber describes some fossil plants, *Otozamites Feistmanteli*, Zigno, and *Pagiophyllum*, indicative of the occurrence of Jurassic strata near Mingenew and Mt. Hill in Western Australia.

Mr. R. Etheridge gives an account of Oolitic Fossils from the Greenough River District. They include the following European species: *Serpula conformis*, Goldf., *Rhynchonella variabilis*, Schloth., *Alectryonia Marshi*, J. Sow., *Ctenostreon pectiniformis*, Schloth., *Pecten* (?) *cinctus*, J. Sow., and *Trigonia Moorei*, Lyc. New species of *Modiola*, *Cucullæa*, *Ostrea*, *Pleurotomaria* are described and figured by Mr. Etheridge. Mr. L. Glauert contributes particulars relating to *Sthenurus occidentalis*, with illustrations; a list of Western Australian fossils; notes on new fossils (Devonian) from the Napier Range, Kimberley; and remarks on the geological age of the Gingin 'Chalk', which is Cretaceous.

Bulletin No. 38 (1910) consists of a well-illustrated report on the Irwin River Coal-field, by Mr. W. D. Campbell. This contains not only an account of the Carboniferous and Permo-Carboniferous strata, but also of the newer and older rocks of the district, and notes on diatomaceous deposits, gypsum, cave guano, and salt.

REPORTS AND PROCEEDINGS.

Geological Society of London: Annual General Meeting.

1. *February* 17, 1911.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The Reports of the Council and of the Library and Museum Committee, proofs of which had been previously distributed to the Fellows, were read. The total number of Fellows on December 31, 1910, was 1,299, being an increase of 5 during the year. No losses had occurred in the Lists of Foreign Members and Foreign Correspondents during the year.

The Balance Sheet for that year showed receipts to the amount of £3,159 17*s*. 2*d*. (excluding £100, the amount of the Hannah Bequest, and the Balance of £178 18*s*. 2*d*. brought forward from 1909), and an Expenditure of £2,985 16*s*. 2*d*.

The Report having been received, the President handed the Wollaston Medal, awarded to Professor Waldemar Christofer Brögger, F.M.G.S., to His Excellency Benjamin Vogt, Minister Plenipotentiary for the Kingdom of Norway, addressing him as follows:—

Your Excellency,—It is most fitting that the medal which bears the honoured name of Wollaston, and was founded by that eminent and philosophical mineralogist, should be awarded to Professor Brögger, who is not only an accomplished chemist and a skilful mineralogist, but a great petrologist. If he had published nothing but his work on these subjects, he would stand in the first rank of living geologists. But he has done far more. His researches on the Cambrian and Ordovician rocks of his own country have proved him to be a brilliant palæontologist and stratigrapher. His detailed mapping and interpretation of the structure of the Christiania area and his explanation of the origin of the Christiania Fjord, have proved him to be a tectonic geologist of the highest order. His researches on the differentiation of rock-magmas have made him one of our foremost teachers of petrogenesis. He has conducted an exhaustive research on the Glacial and post-Glacial changes in Southern Norway, and has expressed his results so cogently that we seem to see with our own eyes the ice-sheets retreating, the seas advancing and retiring, and to feel the climate slowly changing during the deposition of the clays and shell-gravels of your country. He has brought his work on the strand-lines into touch with the ages of man, and has even endeavoured to express these later stages of geological time in terms of years. Nor has his lifework been devoted to science alone; he has served his fellow-countrymen as a member of the National Legislature and his colleagues as the Rector of his University.

But it is not so much the quantity as the quality of Professor Brögger's work that constitutes his claim to the Wollaston Medal. His scientific training has been so thorough, his insight so deep, and his outlook so wide, that in every subject which he has touched his work has become a mine of fact, a model of expression, an example of close and accurate reasoning, and a revelation of new principles. In an age of specialization he is a specialist, but a specialist in almost every branch of his science. That it should have fallen to one man to do so much and so well almost passes belief, but our libraries are enriched by his books and memoirs, and the work of our young men is inspired, improved, and encouraged by his example.

We ask your Excellency to transmit this Medal to Professor Brögger, and with it to convey to him the deepest respect of his British colleagues, and the best wishes of his many friends in this country.

The Norwegian Minister expressed his pride and pleasure in receiving on behalf of his distinguished countryman and friend the highest award which it was in the power of so venerable and learned a Society to confer, and read the following communication which had been sent to him by Professor Brögger:—

"Twenty years ago the Geological Society of London did me the great honour to award me the Murchison Medal. The Society now having awarded to me its highest honour, the Wollaston Medal, I am led to hope that also during the two decenniums that have elapsed, I have been able to yield some contribution of general interest to geological science.

"Allow me on this occasion to assure you that no other appreciation could have been more unexpected or more valued by me than the unanimous award of the Wollaston Medal by the Council of the Geological Society, an honour so surprising to me that even in my dreams I could never have expected to attain it. I am therefore so much the more grateful for this kind valuation of my scientific results.

"The roll of the Wollaston Medal, from the time of its first recipient, the great master, William Smith, until this day, comprises an unsurpassed series of founders and constructors of various branches of geological science. Looking on this roll, comprising also a number of those who were my valued instructors in my youth—the few still living amongst them being now seniors and Nestors of their science—I obtain an excellent scale of the high importance of such an appreciation from the oldest and most renowned Geological Society of the world.

"At the same time, these dear old illustrious names on the roll speak to me as a sad and serious memento of the short lifetime that is left, a reminder to devote the few years that may still remain for me to complete my main lifework, *The History of the Eruptive Province of the Kristiania Region*, the finishing of which, by the force of circumstances, has been interrupted and postponed by official duties for several years.

"Respectfully thanking you for this precious memento, I bow my head, and will do my best to follow its voice.

"W. C. Brögger.

"Kristiania, *February* 9, 1911."

The President then handed the Murchison Medal, awarded to Mr. Richard Hill Tiddeman, M.A., to Professor E. J. Garwood, Sec.G.S., for transmission to the recipient, and addressed him in the following words:—

Professor Garwood,—Ever since the beginning of Mr. Tiddeman's work for the Geological Survey on the borders of Yorkshire and Lancashire, he has kept his eyes open to the observation of exceptional facts and his mind employed in working out explanations for them. Thus he has endowed our science with the fertile suggestions which make workers think on new lines. The excavation of the Victoria Cave, with which he had so much to do, gave us valuable information on the history of the Pleistocene Mammalia; his work on the glaciation of North Lancashire still remains "a model and a basis for Glacial work all over the country"; his observations on the faunas of the Carboniferous 'reef-knolls' of the North of England have put on record a wealth of observation and reasoning which will contribute no little to the solution of the problems presented by those remarkable structures; and his researches upon the raised beaches of Gower covered with Glacial deposits have extended the area of known Pleistocene movement beyond Yorkshire and Cork. Those who have been with him in the field have good cause to be especially grateful to him for the generosity with which he has placed the riches of his knowledge at their disposal. He has helped not only to advance geology but to make geologists, and in so doing has invested his talent at compound interest.

As a member of the Geological Survey, and one of the last of that body who served under Sir Roderick Murchison, he has well merited the award of the medal which bears that honoured name.

Professor Garwood expressed deep regret, which he felt was shared by all present, that a sudden attack of influenza had prevented the recipient from attending in person, and read, in accordance with Mr. Tiddeman's request, the following reply:—

"The award has given me the greatest possible pleasure and satisfaction, and I owe to the President and Council my warmest thanks.

"I regret that I have not done more to merit it; but I hope that I may take the award as signifying that some of my former heresies have been more or less accepted as orthodoxies by my present friends and colleagues, and for this I may go on my way rejoicing.

"R. H. Tiddeman."

In presenting one of the two Lyell Medals, awarded this year, to Dr. Francis Arthur Bather, F.R.S., the President addressed him as follows:—

Dr. Bather,—To devote one's self to the mastery and elucidation of a single group of organisms, and that a large one, demands in most cases so close an application to the study that neither time nor energy is available for other studies or occupations. This, however, has not been the case with you. Outside your own special orders of the Echinoderma, you have dealt with several other groups of the Invertebrata, and have been entrusted with the writing of the British Museum Handbook on the fossil members of this division of the animal kingdom. You have paid attention to the phenomena of denudation by wind as well as to general stratigraphical questions. You have travelled far and frequently in the pursuit of your comparative study of the Foreign and Colonial Museums, and have contributed much information and many valuable suggestions on Museum management, organization, and arrangement to your colleagues in this work. You have brought your ideas and methods for the popular exposition of Geology before the public at the recent International Exhibitions in London, and in more than one case have been exceptionally successful in achieving your objects. You have made yourself a recognized authority on zoological nomenclature.

But these are all by-products. You have ever kept before your mind the steadfast resolve to bring into order, to systematize and classify, and to describe clearly, faithfully, and precisely, certain important fossil forms of the Echinoderma, and especially the Crinoids. I would particularly mention your series of papers on British Fossil Crinoids, your important memoir on the Crinoidea of Gotland, and your latest published work on the Triassic Echinoderms of Bakony. Nor must I omit to add your important contribution on Echinoderma to Sir Ray Lankester's Treatise on Zoology.

In your task you have been so successful that the Council has decided to ask you to accept this year a Lyell Medal, which was intended by its founder to be awarded "for the encouragement of Geology or of any of the allied sciences by which they shall consider Geology to have been most materially advanced".

Dr. Bather, in reply, said:—

Mr. President,—I had thought of much to say on this occasion, but the generous and flattering terms in which you have recounted the things that I have done have made me think rather of those things that I have left undone. If the little that I have done has seemed of such service to Geology as to merit this high distinction, while I am proud to receive it, I cannot forget the friends in all parts of the world who have so greatly facilitated my work by the loan of valuable specimens. And the thought of them again reminds me of the material accumulated, but still untouched. A palæontologist at the British Museum is often envied, much as Dionysius of Syracuse was envied by Damocles. If any Damocles were to take my place he would see, it is true, a rich feast of Cystids and Crinoids laid before him. But the chains of office would perpetually hinder him from feeding, and every day he would dread the fall of a sword in the shape of a peremptory letter demanding the immediate return of some necessary specimen.

It is my hope, sir, that this award by so high a tribunal may convince my friends and superiors that I really have made good use of the rich material entrusted to me; certainly it will encourage me to make my own future labours no less deserving of their continued patience. For these reasons and for many others, which must remain unexpressed, I offer to the Council my heartfelt thanks.

The President then presented the other Lyell Medal to Dr. Arthur Walton Rowe, F.G.S., addressing him as follows:—

Dr. Rowe,—It is no small pleasure to me that it is my duty, as President of the Geological Society, to ask your acceptance of the Lyell Medal which the Council of the Society has awarded to you, in recognition of the great service which you have rendered to British Geology by your researches on the succession and distribution of the zones of the English Chalk. Using delicate and refined means of your own for the development of the fossils, and collecting the latter from the successive horizons with the most scrupulous care, you soon convinced yourself that the key to the evolution of the Echinoids and the basis for their classification was to be found in their succession in time. The first important outcome of your work was the classic paper on the evolution of the genus *Micraster* published by this Society in 1899. The lines of advance in these organisms having thus been made out, you proceeded to use the characteristic forms as time-indices, with the result that you were able, not only to make a satisfactory subdivision of the White Chalk in Kent, but to extend the zonal lines thus marked out throughout the country. In this manner you carried on the work so ably begun by Professor Charles Barrois, and erected a worthy superstructure upon the solid foundations laid by him. The influence which your research has exerted upon other investigators in stimulating them to work, either in direct association with yourself or independently, but always assisted and encouraged by your active help and sympathy, is a sufficient testimony to its value.

Dr. Rowe replied in the following words:—

Mr. President,—That every man is glad to have his work recognized is, I suppose, a truism; but, while I deeply appreciate the all too kind remarks which you have just made, I cannot but feel that the recognition is on far too generous a scale. Very warmly I welcome the reference which you have made to my amateur colleagues in the field. We have but one common aim, and that is to trace the centres of distribution of species in the Chalk, together with their vertical and horizontal range, and especially to work out the fascinating problems in evolution in which that formation is so rich. And, if a certain little biological indiscretion, which I had the temerity to offer to the Council in the year 1899, has borne fruit in this last direction, I shall not regret the anxious complications which attended its somewhat protracted parturition.

But while I claim all praise for the amateur worker, let us not forget the labours of one whose philosophical and masterly grasp of the whole Cretaceous

System has laid us all under a lasting obligation. I refer, of course, to Mr. A. J. Jukes-Browne.

All of us, however, professional and amateur worker alike, owe our allegiance to, and draw our inspiration from, that great Frenchman, Charles Barrois. But for him we should still be floundering in the pre-zonal chaos of a "Chalk with flints" and a "Chalk without flints". As I have said, when speaking in another place, I ask no better verdict from posterity than to be regarded as a faithful exponent of Barrois. Higher praise no worker in the Chalk can ask than this, nor can he attain to higher office.

And, sir, in tendering to you and to the Council my grateful thanks for this high honour, it only remains for me to say that I accept it, not for my own merits, but as a recognition of the splendid achievements of my fellow-workers in this most fruitful field of investigation.

The President, in presenting to Professor Othenio Abel, Ph.D., the Bigsby Medal, addressed him as follows:—

Professor Abel,—The Bigsby Medal has in former years been awarded to workers in many branches of Geology: to stratigraphers, petrologists, palæontologists, and to those whose special subject has been tectonics or physiography. It has been given to the geologists of many lands. It is, however, more than thirty years since it was given to one whose chief work lay in the domain of Vertebrate Palæontology, and it has never yet been awarded to a native of your country.

In awarding it on this occasion, the Council wish to mark their appreciation of your investigations upon the higher Vertebrata, more especially on the Cetacea and Sirenia. Your great memoirs on the Upper Miocene Toothed Whales of Belgium and on the Sirenians of the Mediterranean Territory of Austria are admirable examples of descriptive work, completed by philosophical deductions; while your numerous smaller papers, both on mammals and on lower vertebrates, are full of suggestive speculations based on a detailed study of all the available materials.

The vigour and thoroughness of the work which you have accomplished makes it clear that, in the words of the Founder, "you are not too old for further work," while the number and excellence of your publications prove that "you are not too young to have done much".

Count Alexander Hoyos, Secretary to the Imperial and Royal Austro-Hungarian Embassy, expressed, on behalf of the Ambassador, his Excellency's regret at his unavoidable absence on that occasion, as well as his gratification that so signal an honour had been conferred by the premier Geological Society of the world upon his distinguished fellow-countryman, Professor Abel, and thus for the first time upon a native of Austria.

Professor Abel, having requested permission to use the German language in expressing his thanks, replied as follows:—

Herr Präsident,—Ich bitte, für die Verleihung der Bigsby Gold Medal meinen wärmsten und tiefgefühlten Dank entgegennehmen zu wollen.

Die Zuwendung der Bigsby Medal bedeutet für mich eine ausserordentliche und unerwartete Ehrung, und ich empfinde dieselbe in ihrer ganzen Bedeutung. Ich schätze diese Auszeichnung um so höher, als sie mir gerade von Seiten der Geological Society of London verliehen wurde, der ältesten und unbestritten angesehensten geologischen Gesellschaft der Welt; ihre Mitgliederliste umfasst seit ihrer Gründung bis auf den heutigen Tag Namen, deren Träger auf dem Gebiete der Geologie und Palaeontologie unsere Führer und Meister gewesen sind.

Ich bin stolz darauf als der erste Œsterreicher dieselbe Medaille erhalten zu haben, welche 1877 an Othniel Charles Marsh und 1879 an Edward Drinker Cope verliehen wurde. Aber diese Erinnerung weckt in mir die Besorgnis, ob ich imstande sein werde, mich wie Marsh und Cope in Zukunft der mir verliehenen Auszeichnung nicht unwürdig zu erweisen.

Seit einer Reihe von Jahren mit Untersuchungen über fossile Vertebraten beschäftigt, war es stets mein Bestreben, ihre genetischen Zusammenhänge und Entwicklungswege sowie die Geschichte ihrer Anpassungen zu verfolgen. Auf dem Wege weiterschreitend, den mir mein hochverehrter Freund Louis Dollo gewiesen hat, will ich auch ferner meine ganze Kraft diesen Untersuchungen zuwenden, um mich der mir heute zuteil gewordenen Ehrung nicht unwürdig zu erweisen; die Bigsby Medal wird ein neuer Ansporn für mich sein, in meinen wissenschaftlichen Arbeiten nicht zu erlahmen.

The President then presented the Balance of the Proceeds of the Wollaston Donation Fund to Professor Owen Thomas Jones, M.A., addressing him as follows:—

Professor Jones,—Up to within the last few years the wide-spreading and rugged expanse of Central Wales was tinted upon our geological maps of a uniform pink colour, almost as if it were composed of the strata of a single sub-formation. But, little by little, geologists of the younger generation have been working out the details of its complicated structure, collecting the fossils, and bringing its component rock-groups into line and harmony with their zone-fellows elsewhere. In this work of reformation you have taken a full share. While still a member of the Geological Survey you devoted your holidays to the enthusiastic study of these complicated strata of your native land, and in your Plynlimmon paper you have most successfully unravelled the sequence and structure of that 'heart of Mid-Wales' and of much of the ground to the west. I have much pleasure in handing to you the Balance of the Proceeds of the Wollaston Fund, which the Council has awarded to you in recognition of the good work that you have done, and as an incentive to you to complete it—a task which will be rendered easier by your appointment as Professor of Geology in the University College of Wales at Aberystwyth.

In presenting the Balance of the Proceeds of the Murchison Geological Fund to Mr. Edgar Sterling Cobbold, F.G.S., the President addressed him in the following words:—

Mr. Cobbold,—Although the county of Shropshire was to Murchison a veritable Golconda, he was not able to remove all its treasure or to wrest all its secrets, but left a generous reward for his many successors. Among them, by your excavations in a district rendered difficult by earth-movement and thick soil-covering, you have succeeded in obtaining a new Cambrian sub-fauna and an array of new genera and species of Trilobites. You have not only made important contributions to what was hitherto known of the local succession of the subdivisions of those ancient rocks, but you have by your figures and descriptions added much to our previous knowledge of their fossils. It is appropriate that the Murchison Fund should pass into 'Siluria' and to one working on Older Palæozoic rocks, as a token of the good-will of your fellow-workers, a mark of their pleasure in your achievement, and an expression of their confidence in your future work.

The President then presented to Dr. Charles Gilbert Cullis, F.G.S., the Balance of the Proceeds of the Lyell Geological Fund, addressing him as follows:—

Dr. Cullis,—I need hardly express the pleasure that it gives me to hand the Balance of the Lyell Fund to a colleague for whom I have so much respect, and in whose judgment and ability I place so much confidence. You are able to look back upon a great number of students who have passed out into the world bearing the marks of your training, and you have reason to be proud of the work that they are doing. Your original contribution to the study of the core of the Funafuti Boring, with its careful record and explanation of the occurrence of calcite, aragonite, and dolomite therein; your work on the Forest of Dean and May Hill; and your discovery of the occurrence of dolomite crystals in the Keuper Marls, have all been the fruit of painstaking research, with the gratifying result of forwarding the researches of others. All those who have heard you lecture on your own work or on other geological subjects, have been greatly impressed by your careful choice of matter, the charm of your style, and the lucidity of your expression. Certainly this award is given to one by whom "Geology has been materially advanced".

In presenting an Award from the Proceeds of the Barlow-Jameson Fund to Mr. John Frederick Norman Green, M.A., the President addressed him in the following words:—

Mr. Green,—It is not often that it is given to a geologist to succeed in producing conviction by a single paper, still less by his first contribution to the science; but such has been your good fortune in the paper published by this Society on the rocks of St. Davids. The appropriateness of your methods, your careful recognition of lithological horizons, the accuracy and detailed minuteness of your mapping, even the careful selection of the most conclusive spot for excavation, have engendered such confidence in the result, that we may regard as solved one of the chief difficulties in a most difficult region. The Council has made to you an award from the Barlow-Jameson Fund "for the advancement of Geological Science", in the assurance that you will carry the same accuracy and delicacy of work into other fields.

The President then proceeded to read his Anniversary Address, giving first of all Obituary Notices of several Fellows deceased since the last Annual Meeting, including Prebendary W. H. Egerton (elected a Fellow in 1832); T. R. Polwhele (el. 1858); Major-General W. E. Warrand (el. 1859); Captain G. E. Shelley (el. 1862); the Rev. R. B. Watson (el. 1864); Dr. Theodore Cooke (el. 1866); Mr. C. Fox-Strangways (el. 1873); Mr. A. H. Stokes (el. 1874); the Rev. G. F. Whidborne (el. 1876); Mr. T. M. Heaphy (el. 1876); and Mr. C. Bird (el. 1882).

He then made reference to the chief event of the year in the Society's affairs—the resolution not to continue to maintain the Museum, but to offer its contents to a National Museum or Museums. He pointed out that the unanimous acceptance, at the annual meeting, of the Report of the Council was confirmatory of the action of the special general meeting which had originally passed the resolutions.

The subject of the Address was the consideration of Geology as Geographical Evolution. The main factors of the geographical evolution of an area were considered to be the alternation of upward and downward movement. Each geographical cycle, passing from the period of maximum depression through uplift into terrestrial conditions and then back again towards depression and submergence, would be expressed in the geological record by a corresponding set of deposits consisting of 'thalassic', 'shoreward', 'terrestrial', 'estuarine', and again 'thalassic' deposits following each other in this order. Each of these phases was considered in some detail, and attention was drawn to difficulties in interpretation and correlation, and to the principles according to which the depositional phenomena should be translated into terms of geography.

Despite the fact that several cycles of geography and deposition had swept over Britain, there had been comparatively little repetition of phase in the deposits, and two or three examples were taken to illustrate cases of correspondence and non-correspondence of deposits formed during similar stages in the succeeding cycles. The careful and minute study of existing geographical conditions was strongly advocated, as the key to the interpretation of the geological record; and it was urged that the utmost possible use should be made of palæogeographical maps, both as a means of expressing ascertained fact and as affording a focus for new critical investigation.

The association of the phases of earth-movement with igneous activity was next briefly treated, as also the connexion of movement with rock-structure and existing physiography.

Finally, geographical evolution was examined as the spur to organic evolution, and it was urged upon palæontologists that they should endeavour to ascertain to what extent periods of slow or rapid evolution corresponded with epochs of physical change.

The Ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—COUNCIL: Henry A. Allen; Tempest Anderson, M.D., D.Sc.; Charles William Andrews, B.A., D.Sc., F.R.S.; Henry Howe Arnold-Bemrose, J.P., Sc.D.; George Barrow; Professor Thomas George Bonney, Sc.D., LL.D., F.R.S.; Professor William S. Boulton, B.Sc.; James Vincent Elsden, D.Sc.; John Smith Flett, M.A., D.Sc.; Professor Edmund J. Garwood, M.A.; Sir Archibald Geikie, K.C.B., D.C.L., LL.D., Sc.D., Pres.R.S.; Alfred Harker, M.A., F.R.S.; Robert Stansfield Herries, M.A.; Bedford McNeill, Assoc.R.S.M.; John Edward Marr, Sc.D., F.R.S.; George Thurland Prior, M.A., D.Sc.; Professor Sidney Hugh Reynolds, M.A.; Professor William Johnson Sollas, LL.D., Sc.D., F.R.S.; Aubrey Strahan, Sc.D., F.R.S.; Herbert Henry Thomas, M.A., B.Sc.; Professor W. W. Watts, Sc.D., M.Sc., F.R.S.; the Rev. Henry Hoyte Winwood, M.A.; and Arthur Smith Woodward, LL.D., F.R.S., F.L.S.

OFFICERS:—*President:* Professor W. W. Watts, Sc.D., M.Sc., F.R.S. *Vice-Presidents:* Charles William Andrews, B.A., D.Sc., F.R.S.; Alfred Harker, M.A., F.R.S.; John Edward Marr, Sc.D., F.R.S.; Professor W. J. Sollas, LL.D., Sc.D., F.R.S. *Secretaries:* Professor Edmund J. Garwood, M.A.; Arthur Smith Woodward, LL.D., F.R.S., F.L.S. *Foreign Secretary:* Sir Archibald Geikie, K.C.B., D.C.L., LL.D., Sc.D., Pres.R.S. *Treasurer:* Aubrey Strahan, Sc.D., F.R.S.

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2. *February* 22, 1911.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communication was read:—

"The Geology of the Districts of Worcester, Robertson, and Ashton (Cape Colony)." By R. H. Rastall, M.A., F.G.S.

After a brief description of the physiography of the district and the general sequence of the rocks composing it, in which the incompleteness of the stratigraphical record is especially noted, a detailed account is given of the structure and characters of the Malmesbury rocks of Worcester and the region near that town. These are shown to include a lower and an upper sedimentary series, predominantly gritty and slaty respectively, and evidently of great thickness, probably over 20,000 feet. The upper division is pierced by granitic dykes, which have been subsequently crushed and foliated, forming 'phyllite gneiss'. Certain bands of limestone are metamorphosed by them to pure-white marble. A remarkable isolated mass of igneous rock in Brewels Kloof appears to be intrusive, but the rock is andesitic in character. A thin though conspicuous band of ottrelite-schist has been found in Waai Kloof and in the Hex River Pass. All these rock-types are described in detail. Similar but somewhat less detailed treatment is accorded to the Malmesbury rocks of Robertson and Ashton, and a petrographical description is given of the large granite intrusion of Wolve Kloof, Robertson.

The distribution and characters of the rocks of the Cape and Karroo Systems are only dealt with in so far as they throw light on the principal subject of the paper; but a fairly full description is given of the occurrences of Enon Conglomerate, which is shown to occupy a series of isolated basins, arranged along an east-and-west line, and to lie with a strong discordance upon all the older rocks. After a careful examination of the ground, it is concluded that the Enon Conglomerate does not overlap the Worcester–Swellendam Fault, as indicated in the official maps; and that conglomerate does not appear to contain any fragments of the Malmesbury rocks, which cannot therefore have been exposed when it was formed.

After a careful discussion of all the available evidence it is concluded that the Worcester-Swellendam Fault, which has a maximum throw of probably 10,000 feet, is in great part of post-Cretaceous age, although there are indications of earlier movement along the same line of fracture. From a study of the dominant trend-lines of South-Western Cape Colony it is concluded that the district in question is situated at or near the central line of the syntaxis of two great sets of folds at right angles, which have assumed a fan-shaped arrangement in plan, and that the great fault is a line of fracture and subsidence running transversely across these lines of folding. The folding and the faulting are clearly phases of one general series of events, and the faulting probably resulted from a diminution or even reversal of the pressure which had previously given rise to the folding.

Baron Ferencz Nopcsa, jun., then gave some account of the Geology of Northern Albania. He said that he had examined the greater part of the Province of Scutari in Western Turkey, and recognized three distinct structural units: namely, the North Albanian platform, the folded Čukali, and the eruptive region of Merdita. In the first region Mesozoic limestone of all periods predominates; in the second region Mesozoic radiolarian chert is found; while in the third region Mesozoic clastic rocks, volcanic tuffs, and eruptive masses are abundant. The first and third units are not folded, but are, at least in part, overthrusts from the north and south respectively above the second (intermediate) unit, which is strongly folded. In Northern Albania Upper Carboniferous and Permian rocks are also distinguishable, and there is an Eocene Flysch.

CORRESPONDENCE.

THE HIGH-LEVEL GLACIAL DRIFT AND THE LAND-ICE HYPOTHESIS.

SIR,—In your January number Mr. T. Crook raises an important question concerning the probable method of transport of the boulders and shells which are now found at levels much higher than their probable points of origin. Although he quotes two passages from the writings of Sir Archibald Geikie and Professor Bonney pointing out that it is difficult to understand how the ice could ascend steep slopes to heights of more than a thousand feet, he suggests what seems far more difficult to grasp, i.e. that the lower layers of ice, owing to the formation of internal shear-planes, rose locally to the surface and carried with them portions of the ground moraine.

Being an advocate of the view that an ice-sheet may drag along with it portions of the floor over which it moves, especially if the floor be frozen, and carry such portions up slopes of more than a thousand feet, I do not resent the rendering Mr. Crook gives of such views; neither do I dispute the fact that, as he suggests, upward thrusts and contortions may be seen in glaciers. My experience, however, is that such signs of 'upward thrust', by which I understand him to mean shear, are confined to portions of the glacier where the surface is rapidly melting. In such places the ice is in compression and the glacier surface is rising to make up for the loss.

Thrust is credited with far too much importance as a cause of glacier flow. Rather should we attribute the flow to the absence of support in front. A glacier moves much as does a river. Where the slope is small the velocity of the ice or water is slow and the river or glacier deep; where the river or glacier is wide the flow is slow and

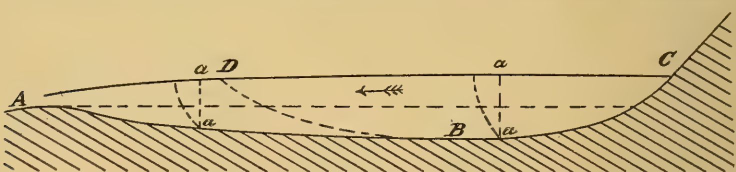

Fig. 1.

the ice or water shallow. Gravity is acting upon every portion of the mass, and the speed and thickness everywhere adjust themselves so as to pass the volume of ice or water to be got rid of. It has been suggested that the forces due to gravity acting on a glacier could not cause shear in its mass; for a similar mass of soft clay would not shear, and clay is much less capable of resisting shear than is ice. Clay, however, is not a viscous substance, and on a slope the material in front acts as a permanent buttress to prevent motion. With ice the front gives way, either by suffering longitudinal compression or by flow, and the rear portions follow.

When large glaciers are concerned the flow is quite regular; there may be shear where the stresses are sufficiently great, but such shear-planes are strictly related to the floor upon or against which the ice rests. Any local upthrust would soon raise a mound on the glacier surface, the weight of which would check further uprise. Many seem to experience difficulty in understanding how a glacier can move up a slope and drag rock masses along with it. Now the movement of a glacier is not necessarily due to the slope upon which it rests. The motion is due to the slope of the upper surface of the ice, which may be in the opposite direction to that of the floor upon which it rests.

We will suppose that the glacier rests in a hollow as in Fig. 1.

Here the upper surface of the ice slopes from C towards A, and the flow is in the same direction. All the ice in the hollow is in equilibrium and is urged in the direction of the arrow by that portion which is above the lip A and extends towards C. Very little force indeed is therefore required to raise the ice from B to A. The ice will get thinner as it advances, and the slope of the upper surface at each point will assume the angle required to deliver the proper volume of ice at any cross section, *aa, aa*.

If the glacier floor were immovable and the ice were frozen to it the rate of motion at the bottom would be very small indeed if local shear did not take place. We have proof, however, that the glacier not only undergoes internal distortion, but that it frequently slips over the floor as well. In Spitzbergen, where the ground is frozen for hundreds of feet in depth, it is clear that ice flowing over such a floor would freeze to it and drag it along. Under these circumstances large masses of frozen gravel and sand would become incorporated in the lower portion of the glacier together with boulders, and these inclusions would be thawed out and redistributed when they came to their journey's end. The 'pushing' effect of the ice front against loose material as the glacier advances is no doubt considerable ; but it is rather to the work effected by the debris-charged lower portion that the transport of material is due.

Mr. Crook suggests that the transport and lifting are more likely to be the result of upward shear in the ice, say along the dotted line BD in the figure, than along the floor from B to A. This seems very unlikely.

If the Rhone Valley were filled with ice up to about the level of the numerous hanging valleys the smaller glaciers from these valleys would flow on to and over the surface of the main Rhone Glacier, and subglacial moraine would thus find its way to the upper levels. I do not think it at all likely, however, that bottom moraine would find its way to the surface by upthrusts in the ice.

R. M. Deeley.

Inglewood, Longcroft Avenue,
Harpenden, Herts.
March 13, 1911.

GEOLOGY OF PADSTOW AND CAMELFORD.

Sir,—In the notice of the Geological Survey Memoir on the Geology of Padstow and Camelford (p. 136) it was stated that the two new maps which accompany that memoir "show, for the first time, the divisions of Lower, Middle, and Upper Devonian". So far as the one-inch maps of the Geological Survey are concerned, this is quite correct. Nevertheless, mention should have been made of the fact that the main divisions of the Devonian rocks had been represented on a small map by Mr. W. A. E. Ussher (Trans. Roy. Cornwall Geol. Soc., 1891, p. 273). That map was constructed from lithological descriptions in De la Beche's Report, the data being interpreted by Mr. Ussher from his intimate knowledge of the Devonian rocks in South Devon. Although the relative position of the Meadfoot and Looe Beds and of the Dartmouth Slates was not then understood, the order of succession of these subdivisions of the Lower Devonian was rectified by Mr. Ussher in 1903 (*Summary of Progress of the Geological Survey for* 1902, p. 160). Thus the main subdivisions in the Devonian rocks of South Devon and Cornwall introduced by Mr. Ussher have been fully confirmed and adopted by the Geological Survey. They are further shown on his Geological Map of Cornwall in the Jubilee Volume of the Geologists' Association, plate xxxii, p. 896 (1910).

REVIEWER.

MISCELLANEOUS.

GEOLOGY AT THE LOCAL GOVERNMENT BOARD.—Mr. J. B. Hill, F.G.S., has just been appointed to the newly-created post of Geological Adviser to the Local Government Board. Mr. Hill joined the staff of the Geological Survey in 1884, and after working among the intricate schistose rocks of Argyllshire was transferred in 1897 to Cornwall. There he surveyed a large area in the neighbourhoods of Falmouth and Truro, and established the pre-Devonian age of the Mylor, Falmouth, and Portscatho Series. On completion of that work Mr. Hill was called on to take part in the re-survey of the Midland area, in the counties of Nottingham, Derby, and Stafford, gaining experience among Carboniferous, Permian, and Triassic rocks, as well as Glacial Drifts.

PRESENTATION TO DR. LAZARUS FLETCHER, F.R.S.—The invaluable services which Dr. Lazarus Fletcher, F.R.S., has rendered to the Mineralogical Society during his twenty-one years' tenure of the office of general secretary have been recognized by the presentation to him of his portrait painted by Mr. Gerald Festus Kelly, A.R.H.A. The subscribers were, however, by no means confined to members of the Society; since Dr. Fletcher resigned his office upon his appointment to the post of Director of the Natural History Museum, many others of his colleagues and friends took advantage of the opportunity to evince the esteem in which they held him by joining in the movement. Just before the anniversary meeting of the Society on November 15 the portrait was presented to him by Professor W. J. Lewis, F.R.S., president, on behalf of the subscribers. Later in the evening Dr. Fletcher was entertained to dinner at the Café Monico, Professor Lewis presiding, and in reply to the toast of his health, proposed in fitting terms by Principal H. A. Miers, F.R.S., delighted his hearers with a witty speech replete with the North Country humour for which he is noted among his friends.

KENTISH NAILBOURNES.—In the *Morning Post* of February 6, 1911, it is mentioned that the intermittent streams or nailbournes of Drellingore, between Folkestone and Dover, the Lyminge stream, and the Petham stream were then flowing, that they were also running last year, and that "there is no record of their having previously run two years in succession". This last remark does not apply to the Petham stream, which on several occasions has been known to flow in successive years, as recorded in Whitaker's *Water Supply of Kent* (Mem. Geol. Survey, 1908), p. 59. In that work full particulars of the nailbournes are given.

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ANDERSON (J. W.). The Prospector's Handbook: Guide for traveller in search of metal-bearing or other minerals. 11th ed. London, 1907. 12mo. Cloth. 1*s.*

ANDREWS (C. W.). A Descriptive Catalogue of the Marine Reptiles of the Oxford Clay, based on the Leeds Collection in the British Museum (Natural History), London. pp. 228. 94 text-figures and 11 plates. London, 1910. 4to. Cloth. £1 5*s.*

BAILY (W. H.). Figures of characteristic British Fossils (Palæozoic Division). London, 1875. 8vo. With 42 plates and 18 woodcuts. Cloth. 10*s.*

BOULENGER (G. A.). Catalogue of the Freshwater Fishes of Africa in the British Museum (Natural History). Vol. i. pp. xi, 373. 270 text-figures. 1909. Imp. 8vo. Cloth. £1 12*s.* 6*d.*

——— Vol. ii. pp. xii, 529. 382 text-figures. 1911. Imp. 8vo. Cloth. £2 5*s.*

CARNOT (A.). Traité d'Analyse des substances minérales. Tome iii: Métaux. Partie i. Paris, 1911. 8vo. pp. 900. Illustrated. £1 2*s.*

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LACROIX (A.). Minéralogie de la France et de ses colonies. Description physique et chimique des minéraux. Etudes des conditions géologiques et leurs gisements. Paris, 1910. 4 vols. 8vo. With numerous illustrations. £5.

LYELL (C.). Principles of Geology. 11th ed. London, 1872. 2 vols. 8vo. Maps, plates, and woodcuts. Cloth. £1 10*s.*

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——— Principles of Geology. 9th ed. London, 1853. Roy. 8vo. With maps, plates, and woodcuts. Cloth. 7*s.*

MOORHEAD (W. K.). The Stone Age in North America. London, 1911. 2 vols. 4to. Cloth. £1 11*s.* 6*d.*

NATAL AND ZULULAND GEOLOGICAL SURVEY.—ANDERSON (W.). Report of the Geological Survey of Natal and Zululand. Pietermaritzburg—London, 1901–7. 3 vols. Roy. 8vo. With plate. Boards. 15*s.*

—— —— Each report separately. 5*s.*

PENCK (A.). Morphologie der Erdoberfläche. Stuttgart, 1894. 2 vols. 8vo. (Anastatischer Neudruck.) £1 12*s.*

POCOCK (R. I.). Arachnida, Scorpiones, Pedipalpi, and Solifugæ. 4to. pp. 71. With 12 plates. (Biologia, Central America.) £1 7*s.*

POTONIÉ (H.). Die Entstehung der Steinkohle und der Kaustobiolithe überhaupt. 5 Aufl. Berlin, 1910. Roy. 8vo. With 75 illustrations. 7*s.* 6*d.*

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TEALL (J. J. HARRIS). British Petrography: with Special Reference to the Igneous Rocks. 1888. Roy. 8vo. 458 pp. of text, with 47 plates, some coloured, bound in cloth extra, gilt top. £3 3*s.* net.

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MAY, 1911.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VIII.

No. V.—MAY, 1911.

With deep regret we record the death of our old and valued friend

Professor Thomas Rupert Jones, F.R.S., F.G.S.,

Editor-in-chief of this Magazine for the first twelve months of its career, 1864–5, who passed away peacefully, after a long and useful life, at "Penbryn", Chesham Bois, Bucks, April 13, 1911, aged 91 years.

He was the author and editor of numerous books and memoirs. From 1850 to 1862, Assistant Secretary to the Geological Society of London, and Editor of the Quarterly Journal.

In 1858 he was appointed Lecturer on Geology at the Royal Military College, Sandhurst, and a resident Professor in 1862; subsequently he served on the Staff College until his retirement in 1880.[1]

ORIGINAL ARTICLES.

I.—Calcite as a Primary Constituent of Igneous Rocks.

By Rachel Workman.

PLATES XI AND XII.

During one of the excursions arranged by the International Geological Congress held in Sweden, 1910, we visited, under the leadership of Professor Högbom, a group of islands skirting the shore north of Sundsvall, on the Gulf of Bothnia. Among these islands Alnö and Långörsholmen are of particular interest on account of a complex of alkali igneous rocks forming the whole of the latter and the northern corner of the former. It is to this small but highly interesting group of rocks that I wish to call the attention of the reader, since apart from the short but convincing 'guide' prepared by Professor Högbom (1), scarcely anything has been written on the subject in the English language. The expedition was very skilfully planned, and we were thus enabled to visit several critical exposures and collect numerous specimens for microscopic study.

As one approaches the two islands mentioned above, a marked change in scenery presents itself. The coast of Sweden is protected,

[1] For his life and works see Geol. Mag., 1893, pp. 1–3 (with a portrait); and op. cit., November, 1909 (Birthday portrait and notice), p. 481. Elected F.G.S. 1852 and F.R.S. in 1872.

as it were, by a fringing archipelago known as the 'skärgård', and the distinctive feature of the numberless lowly islets included in this skärgård is a complete absence of soil and vegetation. Every here and there, bare, smooth, and rounded, granite and gneiss rise out of the sea to a fairly uniform level, beautifully polished and striated—a truly remarkable memorial of the former presence of a great ice-sheet. Only a few Scotch firs have been able to root themselves in cracks and crevices, and except for an occasional coastguard station the solitude is complete. In the midst of this strangely attractive barrenness appears a beautiful fertile oasis, covered with trees, fine meadows, cornfields and prosperous homesteads. It is a merry and hospitable people that has cultivated and developed this little patch, and we have cause gratefully to remember the genial farmers who came forward to welcome us and put at our disposal all the fruits of the earth with the utmost goodwill. They gladly threw open their fields and exposed their property to the searching gaze of the geologist and to the destructive denudation caused by many active hammerers.

One instinctively wonders what produces this remarkable change of scene. It is, in fact, nothing else than the little complex of alkali igneous rocks, responsible for the present paper. The boundary of the oasis is precisely the boundary of this alkali igneous complex, and as one passes outward in all directions on to the surrounding gneiss and granites the landscape again resumes its wonted barrenness.

Primary calcite plays a very important part in the complex under consideration. It is present in all proportions, occasionally forming the main bulk of the rock. Alike in the field and under the microscope it presents all the appearances of a truly igneous constituent. It is found in rocks of every type varying between nepheline-syenite and coarse-grained, banded limestone, in all of them intercrystallized with undecomposed ægirine, nepheline, and other typically igneous minerals. In places, too, it forms calcite pegmatites, showing excellent graphic intergrowth with olivine, mica, and iron ores. It also occurs in fine-grained limestone dykes, cutting both the nepheline-syenite and the coarsely crystalline banded limestones, and bounded by chilled margins against these rocks.

At the edge of the complex where the intrusion comes in contact with the gneiss there are clear indications of marginal assimilation. Quartz appears in the intrusion, no doubt derived from the country rock.

In describing some of the rock-types I will adopt the following order :—

1. The Country Rock.
2. The Plutonic Rocks, including the Massive Limestone.
3. The Dyke Rocks.

1. The Country Rock.

Little need be said of the Country Rock except that it is a coarse, grey, Archæan gneiss, rich in biotite, felspars and quartz. In the neighbourhood of the plutonic intrusion a curious baked variety of gneiss is found, in which all the minerals are surrounded by reaction rims of alkali felspar; around the biotite this alkali felspar occurs in small grains without definite orientation, but around the old felspar (partly kaolinized orthoclase, oligoclase, and perthite) the new water-clear felspar has consolidated in optical continuity. Owing to extensive interaction between the gneiss and the nepheline-syenite, there is a gradual transition from the one to the other through forms in which the original orthoclase, oligoclase, and perthite of the gneiss have been almost completely changed to newly formed microperthite of orthoclase and albite. Quartz meanwhile takes a subordinate position, and ægirine-augite is developed along with sphene and biotite, the latter showing the habit prevalent in the intrusive mass. It is difficult to say where the altered gneiss ends and the acid border facies of the intrusion begins. For convenience Högbom has drawn the outer limit of the nepheline-syenite at the place where quartz first appears in the rock.

2. The Plutonic Rocks.

The two chief types are nepheline-syenite and an almost pure calcite rock or limestone. There is every gradation between these two, depending on the proportion of the constituent minerals. Certain important basic segregations also occur. There is no regular distribution of the different types, and even within one hand-specimen several varieties may be found. No definite order of crystallization among the minerals is to be observed. Sometimes the femic minerals crystallize before the salic, but often the reverse is the case. Calcite as a rule comes last of all.

The chief minerals are—

Pink orthoclase, which contains a noteworthy amount of barium.

Pink nepheline, sometimes seen in beautiful idiomorphic crystals, standing out on weathered surfaces owing to the solution of enclosing calcite. It is occasionally completely altered into acicular zeolites.

Fresh cancrinite. Its primary character is clearly shown by its mode of occurrence in large plates, into which well-defined crystals of felspar and nepheline project, and in which idiomorphic sphene and pyroxene are scattered; in this mode of occurrence it obviously has not been derived from nepheline. It is also found filling up cracks, and is generally the last mineral to crystallize except calcite. The composition of cancrinite corresponds so closely with the assumption that it is a hydrated compound of nepheline and calcite that its presence in these rocks is just what might be expected. Sometimes it is bordered on one side by nepheline, and on the other by calcite, but at the same time it is rare or absent in the limestones even where nepheline is abundant.

Calcite, very prevalent in almost all varieties of these rocks. It is generally the last mineral to crystallize, and is found in allotriomorphic grains. But it also occurs in well-formed crystals, for Högbom (1) has described a fine-grained nepheline-syenite with porphyritic calcite crystals, partly contaminated by syenite minerals.

Pyroxene, either very slightly pleochroic ægirine-augite or more pleochroic ægirine.

Biotite, sparingly found except in the limestones, in the most basic differentiation products, and in the border acid zones, where it has generally crystallized in ragged flakes later than felspar. Phlogopite is not present except in blocks, not found in situ, seen on Långörsholmen which came from the channel between the latter and Alnö.

Melanite or a titaniferous black garnet, abundant in all types either in zoned rhomdodecahedra or in large irregular crystals, whose outline is determined by the surrounding minerals. The zonal character is roughly shown by the variation in colour from a deep black to a brownish tint. It includes ægirine, calcite, nepheline, and sphene. Thus the crystallization of the melanite extended over a long period, beginning early and finishing late. Just such an occurrence is described (2) (3) in the Borolanite, in Assynt, and in some of its more basic associates, which resemble the Alnö rocks in other particulars.

Sphene, irregularly distributed and sometimes very abundant in fine lozenge-shaped crystals; also twinned and with inclusions of apatite, calcite, and ægirine — in this latter case of comparatively late formation.

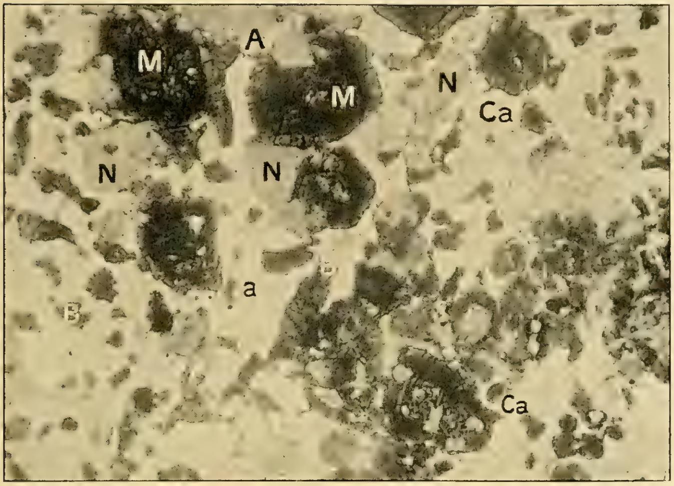
Fluor apatite, free from chlorine, exceedingly abundant. It occurs as grains in the ground-mass and included in the silicates, and also as prismatic crystals arranged in most beautiful stellate rosettes, Pls. XI and XII, Figs. 2 and 3.

Titaniferous magnetite, found mainly in types rich in ferro-magnesian minerals.

Olivine, confined to the basic and ultra-basic groups and to the limestones. It occurs as fresh crystals, deep black in hand-specimen, and also in all stages of serpentinization.

The nepheline-syenites need no special description here. A typical example is shown in Pl. XI, Fig. 1.

The limestones occur in two modes: either granular, when a distinct banding is seen, or pegmatitic. All the minerals of the nepheline-syenites, except cancrinite, are found in them, and in addition the rarer minerals pyrochlor, knoppite, zircon, and manganophyllite; these latter are found in one locality only. The metamorphic contact minerals such as tremolite, diopside, and forsterite, characteristic of impure sedimentary limestones and dolomites, are always absent. Wollastonite has only been recorded by Törnebohm in an isolated instance, and phlogopite seems to be restricted to the loose blocks mentioned above. Where the limestone is free from normal igneous accessory minerals it is exceedingly pure. Analysis has shown that it then consists of 98 per cent. of calcite. The minerals most commonly associated with calcite, where the latter is abundant, are biotite, apatite, titanomagnetite, olivine, felspar, and ægirine-augite. Of these apatite is the commonest and in parts makes up as much as 20 per cent. of the rock. Its characteristic radial development is seen in Pl. XI, Fig. 2, and Pl. XII, Fig. 3. In granular form it often occurs as numerous inclusions in a framework of nepheline and pyroxene. The structure in the limestones is generally hypidiomorphic, but in the pegmatites very beautiful



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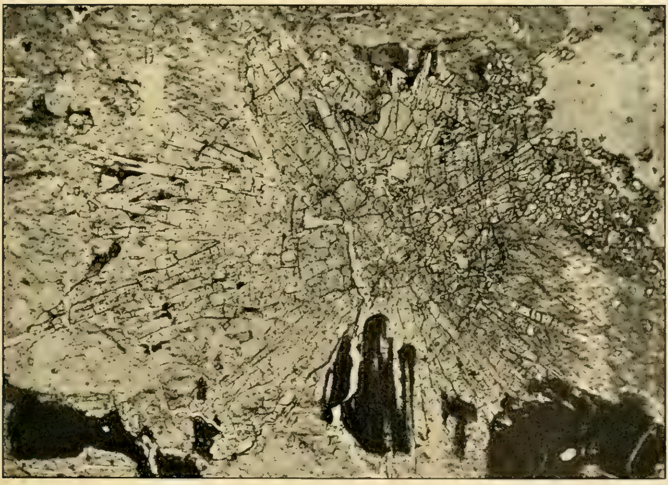

2

1. Nepheline-syenite. × 120.
2. Radial apatite. × 150.

graphic structure can be seen. The calcite shows clearly in the field, where the nepheline and ferro-magnesians have weathered out from it in ribs. At Långörsholmen near the junction with the typical nepheline-syenite, very large crystals of brown mica two or three inches in diameter are seen graphically intergrown with equally large crystals of calcite. Under the microscope the simultaneous extinction of the mica or the calcite, as the case may be, shows very well that this is an intergrowth of individual crystals. As the structure is on a fairly large scale, it is difficult to get a representative area in the field of the microscope, but Pl. XII, Fig. 3, shows a portion of an intergrowth of this character.

Olivine and calcite are also found in graphic intergrowth. In hand-specimens the calcite then shows a curious schiller lustre, and on careful examination a fine network of greenish-brown substance is seen arranged along its cleavage directions. Under the microscope this proves to be olivine, partly fresh but mostly serpentinized. Plate XII, Fig. 4, shows such an intergrowth with magnetite in addition. The latter is probably part of a single individual crystal; the olivine and calcite certainly are.

Numerous inclusions of nepheline-syenite, two or three inches in diameter up to about one foot, are found in the limestone. These may be either magmatic segregations or else inclusions of nepheline-syenite which have been melted and recrystallized by the limestone in a magmatic condition. Around these inclusions fluidal banding is seen gracefully following the contours of the included syenite. It may be mentioned that the banded limestones of plutonic facies recall in many features the banded gabbros and peridotites of Skye and Rum. In fact, the description given by Sir Archibald Geikie and Dr. Teall (4) of the origin of the banded gabbros of Skye could be applied almost word for word to this case. It seems reasonable, therefore, to regard the banding as a result of flow in a heterogeneous magma. It can scarcely be regarded as a bedding structure, for alternating with layers of almost pure calcite are others consisting of ægirine, ægirine-augite, biotite, nepheline, orthoclase, sphene garnet and titano-magnetite. Black 'schlieren', composed almost entirely of dark constituents, occur every here and there. The minerals interlock across the junctions of the bands, so that these latter cannot be due to successive injections; cataclastic structures have not been observed, and there is no field evidence in favour of dynamic action.

There is, in addition to the nepheline-syenite, limestone and rocks of intermediate composition, a great variety of basic differentiation products consisting mainly of biotite, olivine, titaniferous magnetite, apatite, calcite and a pleochroic augite (violet grey to greenish grey). In places, workable titaniferous magnetite ore is associated with these rocks. These differentiation products are present in quite subordinate amounts, but are of great interest to the petrologist. They may be paralleled with the 'Jacupirangite' and other basic differentiation products of an alkali rock series, in association with the titaniferous magnetite of Brazil described by O. A. Derby (5). The Jacupirangite is, it will be remembered, composed of varying proportions of titaniferous pyroxene, titano-magnetite, perofskite, and apatite. The basic rock with which the Alnö titaniferous magnetite is associated and into which it passes may therefore be described as a Jacupirangite, sometimes with more apatite than the type-rock, at others with addition of olivine, and always containing calcite.

3. The Dyke Rocks.

These are mainly Alnöites, nepheline-syenite porphyries, tinguaites, nephelinites, and fine-grained limestones. The best known is the melilite basalt described by Törnebohm as Alnöite. It is found in narrow dykes cutting the syenites, limestones, and surrounding gneisses, and it presents a striking difference from most melilite basalts in carrying abundant large crystals of dark mica one or two inches in diameter. Phenocrysts of biotite, titano-magnetite, ægirine-augite, olivine, and apatite lie in a ground-mass of mica, idiomorphic melilite, and calcite. Other primary constituents are perofskite, chromite, garnet, and pyrrhotine. The conditions necessary for the formation of abundant melilite in this rock in preference to nepheline seems to be a high percentage of lime and aluminium with a correspondingly low percentage of silica and alkali.

A fairly common leucocratic differentiation product is a fine-grained tinguaite, which under the microscope shows a ground-mass of beautiful idiomorphic nepheline and tiny felted needles of pale-green ægirine-augite visible with the high power.

Fine-grained limestone dykes of almost pure carbonate, with a small proportion of silicates, are found in many parts, in the nepheline-syenite as well as in the coarsely crystalline limestone. They both cross other dykes, and are crossed by them. They have all the appearance of true igneous intrusions.

Conclusion.

From the evidence which has been outlined above it is abundantly clear that calcite functions as a primary igneous constituent of the Alnö complex.

A few other instances of this phenomenon may now be mentioned in passing. The Alnö conditions are certainly repeated in a most singular manner at Kuolajärvi, in Finland, for Ramsay & Nyholm (10) have described a nepheline-syenite from this locality containing ægirine, cancrinite, nepheline, orthoclase, sphene, and apatite, and, associated with it, another rock containing ægirine, ægirine-augite, biotite, nepheline, apatite, titano-magnetite, calcite, and zeolites. The primary nature of the cancrinite has been established with great care by Sundell (11); as at Alnö this mineral disappears with incoming of abundant calcite.

Again, at Dungannon, in Ontario, Adams (12) has found calcite in a perfectly fresh nepheline-syenite, enclosed in hornblende, nepheline, plagioclase, felspar, and garnet, in such a manner that he is led to regard it as primary. Another example has been recorded by Sir Thomas Holland (13). In describing a group of alkali eruptive rocks on Sivamalai, in the Charnockite Series, Madras, he says: "The principal feature of interest is connected with the presence of calcite in granular crystals, with apparently as much right, as any of the others, to be considered as a primary constituent. The crystals form isolated granules, and there is apparently no sign of secondary decomposition, or structures which suggest its infiltration into the rock."

More numerous instances might be cited to illustrate the occurrence of primary cancrinite in nepheline-syenites and allied rocks, but this would lead too far afield.

As a rule, in dealing with minerals which have crystallized to form igneous rocks, one does not inquire further into their history after ascertaining their primary nature. But in the case of calcite an exception may be made: this mineral is, in the great majority of cases, formed and concentrated under obviously non-magmatic conditions; and accordingly the question arises, has the Alnö magma incorporated a sedimentary limestone mass?

A very limited example of such incorporation has been demonstrated by Dr. Teall (6, pp. 456, 460), at the contact of the Borolan syenitic complex with the Durness dolomite. At one point a mixed rock has been found, consisting of orthoclase, calcite and ægirine-augite, the latter grown about crystals of diopside which has resulted from the contact alteration of the impure dolomite. Absorption has also been suggested by Daly (7) (8) to account for the presence of the calcite of the Dungannon syenite, and this is not unreasonable, since the latter occurs in close association with sedimentary limestones.

From these cases, and from the well-marked stability of calcite in pure limestones subjected to contact metamorphism, it is clear that an alkali-syenite magma, in which the silica present is thoroughly saturated with bases, may quite well absorb calcite without leading to the dissociation of the mineral. But a sub-alkali magma may be expected to react with any calcite which came to be incorporated, liberating carbon dioxide, and at the same time yielding silicates rich in calcium; such reactions would, of course, only proceed until the magma had been desilicated to a sufficient extent to render any further calcite absorbed immune from attack. It is quite conceivable, for instance, that through the withdrawal of silica in combination with lime, a normal granitic magma might eventually be converted into a variety of felspathoid syenite. From considerations of this character, combined with Lœwinson-Lessing's views (9) that sometimes the assimilation of a small quantity of foreign matter in a magma is sufficient to induce differentiation to a greater or less extent, Daly has been led to regard alkaline rocks in general as derived from sub-alkali magmas through the absorption of limestone, followed by induced differentiation. This view he supports by calling attention to the small relative bulk of alkali magmas, and to the suggestive association of the latter in several cases with limestones, under circumstances which admit of the possibility of important absorption. For Daly, Alnö and Finland offer clear evidence, not merely of the absorption of limestone, but also of the consequent evolution of alkali magmas.

In applying this line of argument to Alnö, however, the question arises, where did such a limestone as is postulated on the absorption theory come from? Högbom is uncertain as to the age of the complex, which he considers probably pre-Cambrian, but possibly Devonian, so that it is conceivable that limestone may have been derived either from the Archæan, or, as a result of 'stoping', from overlying 'orthoceras kalk', which latter has now been entirely swept away by erosion from the surrounding country. But no limestones are known in the Archæan of this region, and the 'orthoceras kalk' is very impure, whereas the Alnö limestone, apart from normal igneous minerals (as opposed to contact minerals), is exceptionally free from contamination.

Högbom's conclusion is, that the calcite has crystallized from the magma in a manner exactly analogous to the other minerals. He suggests that the syenites and limestones may have been separated during the general differentiation of which there is so much evidence among the dyke-rocks of Alnö. But the two cases are not exactly analogous, for the various dyke-rocks present differ from one another in regard to the nature of the minerals, while the syenites and limestones are distinguished by their quantitative but not by their qualitative mineralogical constitution. It is important to notice that the minerals in these plutonic rocks have not concentrated in a definite order; as far as I have been able to judge no definite law for the order of crystallization can be given here. Therefore there is no differentiation due to a regular order of crystallization.

But we shall not digress further into the interesting questions raised by the presence of primary calcite in the igneous complex of Alnö. The main purpose of this paper has been fully attained if it has enabled the reader to form some conception of the unwonted experiences and pleasant surprises which awaited us in this out of the way island, whither we were led by Professor Högbom.

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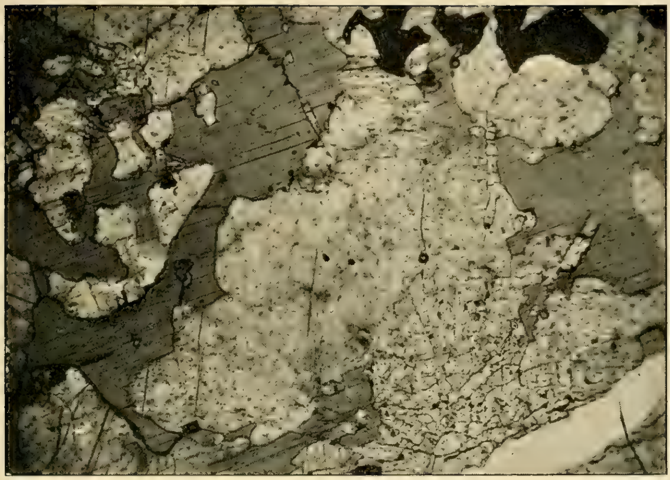

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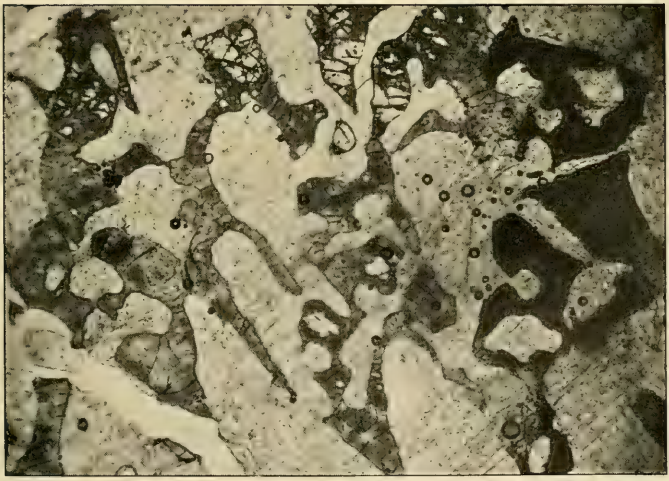

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3. Graphic intergrowth : Mica and Calcite. × 90.
4. Graphic intergrowth: Calcite with Olivine and Magnetite. × 90.

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EXPLANATION OF PLATES XI AND XII.

Plate XI.

Fig. 1. Nepheline-syenite [× 120] showing general structure. M. melanite garnet; N. nepheline; B. ægirine; A. apatite; Ca. calcite.
,, 2. Radial apatite [× 150].

Plate XII.

,, 3. [× 90.] Graphic intergrowth of mica and calcite—radial apatite in upper portion.
,, 4. [× 90.] Graphic intergrowth of calcite with olivine and magnetite.

II.—Note on the Limestone Fragments in the Agglomerate of the "Rock and Spindle" Volcanic Vent, St. Andrews, Fife.

By David Balsillie, St. Andrews.

In the agglomerate of the volcanic necks of Eastern Fifeshire are incorporated, as has long been known, numerous fragments of sedimentary rock. These, it is generally believed, represent the broken-up remains of the strata which at some former time occupied their sites. Many of them have obviously been subjected to excessively high temperatures, others show no sign whatever of igneous action. Thus, occasionally we find quartzites and lydian stone representing what once must have been sandstones and clay shale; or, again, the constituent layers of a sandy or carbonaceous shale may be seen to be still adherent and so little altered as to display on a freshly exposed surface admirably preserved plant-remains. Limestone blocks also occur sometimes converted into marble, frequently unchanged; in the latter case, exhibiting on their weathered exteriors the remains of those organisms which give at once the clue to the conditions accompanying the deposition of their parent stratum. It is with special reference to these limestone fragments that this note has been written and particularly to those occurring in one vent—the well-known "Rock and Spindle"—a mile and a half to the east of St. Andrews.

To be quite brief, the "Rock and Spindle" volcanic vent can now be seen to penetrate a portion of that group of Lower Carboniferous sediments which in Central Scotland is known as the Calciferous Sandstones. Intercalated among the strata through which it has risen is one well-known limestone band, the Encrinite-bed. Numerous fragments of this calcareous stratum are, of course, to be found in the agglomerate just as we should expect. In addition to these, however—and the fact does not seem to have been formerly emphasized—are frequent pieces of a white limestone which in the immediate neighbourhood has no counterpart. From these last-mentioned fragments I have at one time or another obtained the following fossils. Most of them were collected in the north-western portion of the vent, and especially did they occur in the decomposed blocks above high-water mark.

Lithostrotion irregulare, Phill.
L. junceum, Flem.
Zaphrentis sp.
Crinoid ossicles (many large).
Echinoid spines and plates.
Batostomella sp.
Rhabdomeson rhombiferum, Phill.
Athyris ambigua, Sow.
Orthis resupinata, Mart.
Productus semireticulatus, Mart., var.
Productus, several species indet.
Productus spines.
Rhynchonella pleurodon, Phill.
Aviculopecten sp.
Nucula gibbosa, Flem.
Nuculana attenuata, Flem.
Bellerophon Urei, Flem.
B. decussatus, Flem.
Loxonema sp.
Macrochilina sp. (*imbricata*?), Sow.
Pleurotomaria sp.
Orthoceras sp.

About this assemblage of fossils there is something that is here peculiar. Suppose I were requested to collect such a suite from the stratified rocks of North-Eastern Fife I should certainly not go to any portion of the Calciferous Sandstones (the strata through which the agglomerate can be seen to rise), but to some of the well-marked marine horizons in the lower portion (Lower Limestones) of the next overlying group of sediments, the Carboniferous Limestones. It would, of course, be natural to expect that the fragments which furnished the foregoing list of fossils must have been derived from some calcareous stratum underlying this precise portion of the coast-line anterior to the volcanic outburst. As has been said, however, the only known limestone at this part is the Encrinite-bed, but from that horizon the following species have not so far been obtained—*Lithostrotion irregulare*, *Zaphrentis*, and *Orthis resupinata*. In addition to this the mode of occurrence of the corals is quite different from that in the Encrinite-bed. Blocks are found entirely made up of the cylindrical corallites of *Lithostrotion*, and are just such as we should expect to have been derived from some of the Lower Limestones. Again, the size of the blocks renders an Encrinite-bed parentage improbable; one at the upper part of the beach was found to measure 20 × 14 × 12 inches, and the Encrinite-bed in the near vicinity is only some 5 inches thick.

Having therefore established the fact that these limestone fragments belong to a higher stratigraphical horizon than any through which the vent can now be seen to rise, how can their presence here be accounted for? The most probable explanation appears to be that some at least of the Lower Limestones formerly overspread this portion of the county, and were actually penetrated by the vent. The disrupted fragments were enclosed in the agglomerate which subsequently subsided within the orifice, while the overlying and surrounding sedimentary rocks have been entirely swept away.

III.—On some British Pillow-lavas and the Rocks associated with them.

By Henry Dewey and John Smith Flett.

(By permission of the Director of H.M. Geological Survey.)

The pillow-lavas are a group of basic igneous rocks that occur, in our experience, only as submarine flows, and very frequently exhibit 'pillow-structure'. A lava-flow of this type is composed of sack-shaped masses, globular or elongated, and varying in size. The external surface of the pillows may be compact, but in their interior there are numerous cavities often concentrically arranged. First described in Britain by Nicholas Whitley (1), and figured also by De la Beche (2), they have become generally known through the work of Teall (3), Raisin (4), Reid and Dewey (5), and their importance among the Palæozoic eruptive rocks of Britain is now well established.

Although pillow-structure is rarely completely absent, it may not be well exhibited in every exposure of these rocks, especially when, as in Cornwall and Devon, they have been exposed to earth-movements and folding. On the other hand, pillow-structure may make its appearance in rocks that do not strictly belong to this group. Thus it is sometimes seen in the Carboniferous basalts of the Lothians and Fife (6), though not well developed.

The name spilites was given to rocks of this class by Brongniart (7) in 1827, and has recently, in accordance with the usage of Continental petrographers, been adopted by the Geological Survey to designate the Carboniferous, Devonian, and Ordovician pillow-lavas of Devon and Cornwall. It was first used in English by Bonney (8) for certain rocks in Jersey that seem to be properly included in this group.

In addition to the pillow-structure there are certain characteristics that mark the spilites of Great Britain. The first of these is that they are as a rule very completely decomposed, and the second that their felspars are always rich in soda. Their micro-structure varies within rather narrow limits. The principal component is felspar; next in importance is augite of pale-brown colour; remains of olivine are sometimes, though not often, to be detected. Frequently they seem to have contained a fair amount of glassy base, though this is always devitrified and decomposed. Their felspars are occasionally micro-porphyritic, and often those of the ground-mass have pointed or acicular forms. A few British spilites have large felspar phenocrysts. Sometimes they consist almost wholly of felspar laths with a fluidal arrangement. A large number of spilites are variolitic, and in these the augite may occur as irregular masses enclosing the ends of felspar rods, so that the structure may be described as sub-ophitic.

The advanced decomposition exhibited by the vast majority of these rocks has led to their being classed as 'diabase-porphyrites'; and when they are sheared they form typical 'schalsteins'. We find these characters not only in the pre-Cambrian and Ordovician spilites. In Cornwall the Devonian and Carboniferous spilites and schalsteins never contain olivine or augite, but their ferro-magnesian minerals are completely replaced by secondary products (chlorite, calcite, and epidote).

The felspar is sometimes decomposed beyond identification. Dr. Teall (9) was the first to determine its real nature in the pillow-lavas of the Southern Uplands of Scotland. He recognized it as oligoclase, and confirmed this identification by chemical analyses. We have examined hundreds of sections of spilites from Cornwall and Devon, and have found that the only felspar they contain is albite or albite-oligoclase.

There are two ready tests by which this felspar can be recognized. It has all indices of refraction lower than that of Canada balsam, which in the slides made for the Geological Survey has very closely the refractive index of the ordinary ray of quartz (1·544), and in convergent light it has positive optical sign. These tests exclude all felspars more rich in lime than oligoclase-albite, and are better than any methods depending on extinction angles. The only difficulty in applying them is that the felspar is often filled with minute grains of chlorite and epidote. We shall see that chemical analyses have in several cases placed the identity of the felspar beyond question.

The albite is sometimes very clear and transparent, suspiciously so when we remember the highly decomposed state of the rocks in which it occurs. At other times it has a milky translucency, while in many rocks it is filled with infinitesimal grains of chlorite or epidote. Hence there is reason to believe that in some degree the soda-felspar may be secondary, and that possibly the rocks have been albitized. Now albitization, or the replacement of other felspars by albite, takes place in many ways, as might be expected in a phenomenon so generally displayed by the older igneous rocks. Apparently it is sometimes a result of ordinary processes of weathering by which albite and calcite or epidote replace lime-soda plagioclase. Among the best instances of this type the rocks of Bardon Hill in Charnwood Forest may be adduced. Their felspars were zonal with basic centres, and the interior of the crystals is now a meshwork of albite enclosing many grains of epidote, while the margins are nearly solid albite. Albite and epidote or zoisite may also arise from lime-soda felspar through shearing, as in many of the amphibolites derived by movement from the basic intrusive rocks of the North-East Highlands of Scotland. But albite also replaces lime-soda felspar by a process of albitization, as Bailey and Grabham (10) have shown, which may be a juvenile, post-volcanic, or pneumatolytic mode of alteration.

In the Cornish pillow-lavas the felspars occur in several distinct states. They may be entirely replaced by calcite, quartz, and sericite, as in many lavas of Brentor. In other rocks the lath-shaped sections of felspar are a network of albite with the interstices occupied by secondary minerals such as chlorite and calcite. We can hardly avoid the suspicion that what lime felspar was originally present has been dissolved out, as in the rocks described by Termier (11) and the gaps filled in with decomposition products. But in a fair number of the rocks of this class the albite is clear and fresh, by no means very full of inclusions, and has much of the appearance of a primary mineral. Yet all the other components of these spilites have been completely decomposed; no augite can be found in them, and the matrix is a dense aggregation of secondary products. An example of this class is furnished by the lava of Devonport Workhouse near Plymouth (12). Its albite crystals are not zonal except that their interior is rather spongy and full of secondary inclusions, while their external portions are compact.

In rocks of this type it must be conceded that albitization of soda-lime felspar has occurred on a not inconsiderable scale. We believe that this is to be ascribed to a pneumatolytic change that affected the spilites very shortly after their effusion. It must be remembered these are only the westward prolongation of a great series of pillow-lavas (13) (with attendant keratophyres, minverites, etc.) that extend from Moravia through Nassau across the Rhine into England. Many accounts of these Devonian schalsteins have been furnished by Continental petrographers. Some have noticed their richness in soda, but other felspars are often described as characterizing this group of rocks. Many of them contain fresh augite and labradorite or andesine, in others the felspar is partly oligoclase. The Devonian spilites of the West of England contain no pyroxene and no felspar but albite. Yet there can be no doubt that they are the effusive rocks of one eruptive period, furnishing one of the best examples of a petrographical province that could be adduced. Hence, as the most decomposed rocks contain most albite it seems reasonable to assume that the mineral is in some way of secondary origin.

In these rocks albite occurs sometimes in vesicles and veins, but the minerals of the amygdules are mostly calcite, chlorite, and quartz. The highest lavas of the series are interbedded in the Lower Carboniferous. At the close of the Carboniferous period the Armorican earth-movements began. The spilites were crushed and, when highly vesicular, were torn in shreds. Their felspars are broken and twisted, and the evidence of the slides proves that before the movements set in the albitization and decomposition were complete, for the broken albites are not healed or their fractured surfaces united by new deposit.

Shortly after the movements ceased (perhaps before they were completely at an end) great eruptive granites, of which the Dartmoor mass is the best known, invaded the region. The lavas were at that time rotten and sheared, and their vesicles filled with secondary minerals. Within the aureoles of the granite bosses they were now hornfelsed and their albite felspar replaced by andesine and labradorite, while their calcite and chlorite gave rise to epidote, augite, biotite, and hornblende. The basic felspar can be traced in every stage of development as we follow the spilitic lavas from the outer precincts of the aureoles to the actual contacts with the granite; and that the felspar is recrystallized from a mineral that was full of secondary products can be proved by the abundance in it of specks of hornblende, augite, and biotite, that gradually coalesce to larger grains as the alteration becomes more intense. The new basic felspar produced in this way in late Carboniferous times is still perfectly fresh and clear; this proves that some factor other than mere lapse of time with concomitant weathering must be regarded as the prime agency of albitization in this case.

To show the chemical composition of these rocks we quote some analyses that have been prepared in the laboratory of the Geological Survey. These demonstrate clearly the essential characters of the group: they are basic rocks much decomposed and rich in carbonates and combined water. In all cases the soda is high for basic rocks, while the potash is very low. If the carbonic acid of the first, second, and third analyses is assumed to be combined with lime to form calcite, an assumption that has been verified by chemical tests, the amount of lime felspar present must be quite negligible.

ANALYSES OF BRITISH SPILITES.

	I.	II.	III.	IV.
SiO_2	51·31	46·4	47·56	40·55
TiO_2	1·92	·24	2·40	2·95
Al_2O_3	12·67	20·4	14·27	16·65
Fe_2O_3	·54	6·9	1·63	1·13
FeO	7·99		6·80	9·46
MnO	·45	—	·30	·20
$(CoNi)O$	?trace	—	·08	·07
BaO	nt. fd.	—	nt. fd.	nt. fd.[1]
CaO	8·17	7·7	10·95	6·06
MgO	2·19	3·5	4·90	5·20
K_2O	·54	·54	·27	·27
Na_2O	5·21	6·93	4·61	4·76
Li_2O	?trace	—	?trace	?trace
H_2O (at 105° C.)	·04	—	·42	·27
H_2O (above 105° C.)	2·31	1·1	2·65	3·89
P_2O_5	·90	—	·19	·73
FeS_2	·30	—	·22	—
S	—	—	—	·10
Fe_7S_8	·17	—	·05	—
CO_2	6·15	5·8	2·95	7·85
	100·86	99·51	100·25	100·14

I. West side of Tayvallich Peninsula, Argyllshire (analysed by E. G. Radley, S. 12453).

II. Gatelochside Burn, near New Cumnock, Ayrshire (analysed by J. J. H. Teall). "The Silurian Rocks of Britain"; vol. i, Scotland: Mem. Geol. Surv., 1899, p. 85.

III. Tregedden, South Cornwall (analysed by E. G. Radley, E. 5791).

IV. Devonport Workhouse Quarry (analysed by W. Pollard). "The Geology of the Country around Plymouth and Liskeard": Mem. Geol. Surv., 1907, p. 97.

The Albite-diabases.

With the spilites both in Europe and America, diabases invariably occur, representing the intrusive magma that consolidated below the surface. Some of them contained olivine, but their characteristic minerals are purplish augite (of various shades), plagioclase felspar, and titaniferous iron-ores. Like the spilites they are rarely fresh; their olivine is always decomposed and their augite is frequently replaced by chlorite, epidote, and calcite, though it is far more commonly in good preservation than the pyroxene of the spilites. The only felspar in the vast majority of these rocks is albite, and it is often present in surprising quantity. That basic plagioclase originally formed the inner zones of many felspar crystals may be assumed from the frequency with which the albite has a spongy centre filled with epidote, prehnite, and chlorite, while the margins are compact. But in these diabases veins and segregations occur that are of paler colour and especially rich in soda-felspar, in fact they are almost pure albite rocks. Instances may be cited from Newlyn Quarry, Cornwall (14), and Trusham in Devon, and similar rocks have been described from Germany by Brauns (15). On analysis many of the

[1] A substance is reported as not found (nt. fd.) when, though searched for in the usual way, no traces of it have been obtained by the analyst.

diabases differ but little from ordinary diabases except in the slightly higher percentage of soda that they contain. Others, however, contain as much as 5 per cent. of soda, an unusual amount for rocks of this type. There can be no doubt that they are a basic group characterized by abundant alkalies and hence possessing affinities with essexite, as has been recognized by Flett (16), Ehrmannsdorfer (17), and Weber (18).

It is equally certain that in some cases they have been albitized and have had additional soda-felspar introduced after they had consolidated. An example occurs in the Kit Hill diabase (19). It has large rectangular felspars with interstitial anidiomorphic augite and iron-ores. The two last-named minerals are rather decomposed, but the felspar is very fresh, clear, and homogeneous. It occurs in fairly large crystals which are not zoned, and it has the optical properties of albite. By means of bromoform it was separated from the crushed powder of the rock, and analyses confirmed the optical tests by showing that it was almost chemically pure albite.

In Cornwall and Devon the albite-diabases, like the spilites, were completely decomposed and albitized before the late Carboniferous earth-movements, and were hornfelsed by the granites. Their soda-felspar was then replaced by andesine and labradorite, which is still in excellent preservation. Here again it is certain that the albitization ensued very soon after the rocks were intruded, and we infer that it was of pneumatolytic character.

Minverites (Proterobases).

Certain rocks from North and East Cornwall that were described by Teall (20) as hornblendic diabases were subsequently described by Flett (21) as proterobases. In 1910 Dewey (22) proposed the name minverite for similar rocks from St. Minver, North Cornwall. They are much like the diabases, but contain fresh brown primary hornblende. Sometimes traces of olivine (never fresh) occur in them; they are not usually ophitic, and contain much brown and purplish augite. Primary alkali-felspar, mostly albite, is often abundant in the minverites. Analyses of these rocks from Cartuther and St. Mabyn show that they are of the sub-alkalic group of basic rocks, very close in many respects to the essexites. Often they contained a limited amount of lime-soda felspar, now replaced by albite, epidote, and prehnite, or in some cases almost wholly albitized. Other features of this group are the striking abundance of apatite in long thin prisms, and the occasional presence of deep-brown biotite. At Polyphant they are closely associated with the hornblende picrites.

Quartz-diabases.

Here and there in Cornwall quartz-diabases (23) occur among the spilites and albite-diabases, and belong to the same volcanic epoch. Yet in these rocks the basic felspars remain, every zone is perfectly distinct, the most basic in the interior, the most acid externally. Clearly, then, the albitization is a process intimately connected with the nature of the individual rock; the spilites and quartz-free diabases show it, but the quartz-diabases do not. We are reminded of the manner in which some granites are attended by pneumatolytic phenomena (formation of greisen, etc.) while others are practically free from them. Bailey & Grabham (24) showed that the quartz-diabases of Scotland are occasionally albitized, but only locally and incompletely.

Picrites.

Several picrites have been recorded from Cornwall and Devon, mostly hornblende picrites. Similar rocks occur in the Devonian of the Rhine. They contain a little felspar, usually labradorite or bytownite, and, as in the quartz-diabases, it is not albitized.

ANALYSES OF ALBITE-DIABASES, MINVERITE, AND PICRITE.

	I.	II.	III.	IV.
SiO_2	59·84	46·73	47·19	39·14
TiO_2	·64	2·74	2·09	1·66
Al_2O_3	15·71	18·73	13·96	7·59
Fe_2O_3	1·68	nt. fd.	3·39	5·26
FeO	7·03	10·14	9·01	8·76
MnO	·12	·37	·47	·56
$(CoNi)O$	—	—	·04	·11
CaO	3·71	8·62	8·08	5·91
MgO	1·37	3·56	7·10	22·78
BaO	—	—	·06	nt. fd.
K_2O	2·76	·88	·70	1·09
Na_2O	6·52	3·54	4·50	·60
S	·10	—	—	—
FeS_2	—	·05	·11	—
CO_2	—	·58	·79	—
P_2O_5	·20	·37	·56	·38
H_2O (at 105° C.)	·14	·35	·12	·56
H_2O (above 105° C.)	·31	3·31	2·56	6·30
	100·13	99·97	100·73	100·70

I. Gwavas Quarry, Newlyn, Cornwall (analysed by W. Pollard). "The Geology of the Land's End District": Mem. Geol. Surv., 1907, p. 35.

II. Albite-diabase, Trusham Station Quarry, west side of Teign, Devon (analysed by E. G. Radley, E. 6808).

III. Proterobase, 200 yards north of viaduct, south-west of Cartuther, Cornwall (analysed by W. Pollard). "The Geology of the Country around Plymouth and Liskeard": Mem. Geol. Surv., 1907, p. 100.

IV. Hornblende picrite, Criffle Mill, Molenick, Cornwall (analysed by E. G. Radley). Ibid., p. 101.

The rocks that we have considered are of basic or ultra-basic composition, but acid and intermediate rocks also accompany the pillow-lavas. Of these we may distinguish the keratophyres (and albite-trachytes), quartz-keratophyres (and soda-felsites), and the soda-granites.

Keratophyres, etc.

The keratophyres are typically quartz-free. They consist of albite, chlorite, and iron-ores, and the structure varies from orthophyric to porphyritic; the phenocrysts are anorthoclase or albite. First described by Teall from the Southern Uplands of Scotland (25), and subsequently from Mevagissey in Cornwall (26), they have been found also in association with the pillow-lavas of Tayvallich (27), and the variolites of Fishguard (28). Quartz-keratophyres contain usually phenocrysts of corroded quartz and albite or anorthoclase, in a matrix that may be felsitic or microcrystalline. The soda-felsites are often strikingly perlitic. Quartz-keratophyres are common in Devon with the pillow-lavas there, and soda-felsites occur in the Southern Uplands of Scotland.

Soda-granites.

The soda-granites are coarse-grained rocks, generally with phenocrysts of albite. The matrix is a holocrystalline mixture of quartz and albite. Ferromagnesian minerals are rare, but include biotite and pyroxene, the latter represented only by pseudomorphs. Rocks of this class occur at Porthallow in South Cornwall, where they are intrusive in the Ordovician pillow-lavas; and at Tayvallich in Argyllshire they penetrate the spilites that are interbedded with the limestones and schists of the Central Highland metamorphic series.

ANALYSES OF KERATOPHYRES, SODA-FELSITES, ETC.

	I.	II.	III.	IV.	V.
SiO_2	64·38	66·05	79·64	72·51	65·67
TiO_2	—	·49	·50	·31	·19
Al_2O_3	16·98	13·29	11·44	13·10	13·72
Fe_2O_3	4·04	3·22	·11	2·81	·50
FeO	—	5·07	·30	·90	1·17
MnO	—	—	·08	·20	·13
CaO	1·08	·50	·71	1·84	3·21
$(CoNi)O$	—	—	—	—	·02
BaO	—	—	—	—	·04
MgO	·28	1·36	·15	·20	1·52
Na_2O	7·57	6·67	6·40	6·76	6·26
K_2O	4·30	·87	·38	·33	1·68
Loss on ignition	1·64	1·88	·30	·35	·84
H_2O (at 105° C.)	—	·96	·16	·04	·28
P_2O_5	—	·09	·08	·06	·09
CO_2	—	—	·02	·76	4·86
FeS_2	—	—	—	—	·03
	100·27	100·45	100·27	100·17	100·21

I. Keratophyre, Hamilton Hill (analysed by J. J. H. Teall). "The Silurian Rocks of Scotland": Mem. Geol. Surv., 1899, pp. 88–9.
II. Keratophyre, Trevennen (analysed by W. Pollard). "The Geology of the Country around Mevagissey": Mem. Geol. Surv., 1907, p. 56.
III. Soda-rhyolite, west side of Skomer Island, top of cliff west of the spit (analysed by E. G. Radley, E. 7768).
IV. Soda-granite, Tayvallich, Argyllshire (analysed by E. G. Radley, S. 13221).
V. Soda-granite, north corner of Porthallow Cove, Cornwall (analysed by E. G. Radley, E. 6377).

We have, then, a long and varied suite of igneous rocks belonging to the spilite association. The commonest are always spilite and diabase; next in abundance are keratophyres and quartz-keratophyres; less frequently we find soda-granite, minverite, and picrite. They range from ultra-basic rocks like picrite to highly acid quartz-keratophyres, and their chief characteristic is the abundance of soda, even in the basic types. A close parallel can be drawn between them and the picrites (teschenites), dolerites and basalts, trachytes, and rhyolites of the Carboniferous rocks of Scotland (29). In both series felspar-free rocks occur (picrites and peridotites) and quartz-diabases, otherwise the spilite suite is always the richer in soda, and shows an additional characteristic, the almost universal and often complete albitization of the lime-soda felspars.

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

IV.—A New Pleistocene Fauna from Tokyo, with a General Statement on the Pleistocene Deposits of Tokyo, Japan.

By Dr. H. YABE, Geological Institute, University, Tokyo, Japan.

JUST before my departure from Tokyo to Europe, in 1908, my attention was called, by the kindness of Mr. Gordon Yamakawa, to a fossil fauna from a cutting along the Yamanote line of the circum-Tokyo railway, near the Tabata station. It was seven years ago, when the railway line was still in process of construction, that Mr. Yamakawa formed a collection of fossils, consisting exclusively of molluscan remains. Of special interest is the abundant occurrence of *Tellina venulosa*, Schrenk, in the shell-sand, and as its presence is really of exceptional interest in the environs of Tokyo we visited the place together soon afterwards. The present brief account is contributed partly for the purpose of recording the observations of this diligent young student of fossils, whose lamentable and too early death took place last autumn, during my absence in Europe, and partly with the intention of interesting others in the further study of the Pleistocene and Pliocene geology of Tokyo, which though apparently quite simple, contains many interesting and unsettled geological questions.

The surface of Tokyo is topographically divisible into two parts: higher terrace-land and lower alluvial plain, as very well expressed by our plain terms *Takadai* and *Shitamachi*. The change from the first to the second is usually abrupt, with the average difference of 15 metres in height, and marked by a series of nearly vertical bluffs; for instance, the ridge connecting Ueno and Asukayama is merely the vertically cut end of the terrace land, which trends S.E.–N.W., and faces N.E. Along the very foot of the ridge lies the Owu line of railway; the above-mentioned Tabata station is situated about two miles N.W. of Ueno, and there the Yamanote line branches out from the Owu line and enters into a cutting through the terrace land. The fossil locality visited by us is situated just in the entrance to this cutting.

The greater part of the cutting, about 12 metres in height, was already grass-covered, but evidently consisted of loam and the underlying thick sandy gravel bed. The latter was succeeded by a bed of brownish sand, about one-third of a metre thick, which is very variable in character and liable in a short distance to pass into an argillaceous sand or an arenaceous clay. The remaining lower part of the cutting, about 2 metres in thickness, was already to our great regret enclosed by a stone wall, just at the spot where Mr. Yamakawa had made his collection of fossils; at a little distance from the spot, however, we could actually examine brownish arenaceous clay, full of vertical pipes, exhibited on the same level as that of the recently exposed and now hidden shell-sand. This arenaceous clay passes gradually upward to the above-mentioned brownish sand; no marked stratigraphical boundary is recognizable between these. That the distribution of the shell-sand was confined to a very limited area was also obvious from the present widely scattered remains of the once excavated fossil shells over the floor of the cutting, and also in an open drain.

Only 200 metres or a little more distant from the place are two, long abandoned, great sand-ditches along the Owu line, where very prolific shell-beds were once exposed. The detailed account of these fossiliferous beds and their contained fossils are given by Mr. S. Tokunaga[1] in his work "Fossils from the Environs of Tokyo", 1906, from which the following lines are quoted for the sake of comparison :—

"The brownish and bluish clay layers at the bottom of my profile [which on p. 93 shows the downward succession of loam 5·78 metres, clay 0·6 metre, gravel 6·0 metres, and brownish and bluish clay] contain different kinds of fossils at different parts even of the same horizon. In some parts we find numerous plant-leaves, while in others trunks of trees and shells. Where the shells are numerous, the clay passes into sands. . . . Below the clays is found a bluish sand which yields some molluscan casts at Shinagawa and Oji, and numerous shells at Tabata. At the last locality no bed lower than this sand is exposed. But at Shinagawa and Oji there is a sand with numerous shells, showing a wavy line of boundary against the overlying sand on natural profiles."

It may be here remarked that the boundary question of Diluvium and Pliocene was much discussed by D. Brauns, T. Suzuki, Tokunaga, and others, in reference to this wavy line above the principal shell-bed of Oji. A similar and even sharper wavy line is seen between the sandy gravel bed and the underlying brown clay at Tabata; at the end of this paper the question will be shortly referred to.

MOLLUSCA, ETC., FROM THE SHELL-BEARING SANDS AND OVERLYING ARGILLACEOUS BED OF TABATA.

MOLLUSCA.

GASTEROPODA.

Rapana bezoar, L.
Nassa japonica, A. Ad.
N. livescens, Phil.
Columbella martensi, Lischke.
C. pumila, Dkr.
Drillia tabatensis, Tok.
Natica ampla, Rve.
Scalaria lamellosa, Lam.
Eulima ovalis, Tok.
Pyramidella spirata, A. Ad.
P. cinctella, A. Ad.
Cerithium nipporiensis, Tok.
Cerithiopsis tabatensis, Tok.
Lampania zonale, Brüg.
Potamides fluviatilis, Potiez & Mich.
Rissoa (*Fenella*) cf. *cerithina*, Phil.
R. septentrionalis, Tok.
R. subcylindrica, Tok.
Rotella costata, Lesson, var. *superbus*, Gld.
Turbo granulatus, Gmel.
Acmæa conulus, Dkr.
Patella (*Heliconiscus*) *amussiata*, Reeve.
Tornatina exilis, Dkr.
Ringicula arctata, Gld.
Cylichna musashiensis, Tok.
Bulimella obtusa, Tok.

LAMELLIBRANCHIA (or PELECYPODA).

Martesia striata, L.
Solen krusensterni, Schrenk.
Saxicava arctica, Desh.
Tellina jedoensis, Lischke.
T. serricostata, Tok.
Macoma nasuta, Conrad.
Cyclina chinensis, Chem.
Tapes decussata, Dkr., var. *philippinarum*, Ad. & Rve.
Lasæa striata, Tok.
Arca inflata, Rve.
A. tenuis, Tok.
A. granosa, L.
Modiola modiolus, L.
Anomia aff. *patelliformis*, L.
Ostrea tokunagai, Cossmann.

PISCES.

Myliobatis sp.

MAMMALIA.

Elephas antiquus, Fal.
Indeterminable ungulate bones.

[1] Journ. Coll. Sci. Tokyo, vol. xxi, art. 2, p. 93, 1906.

Mr. Tokunaga enumerated the above list of fossils from the principal shell-bearing sands and overlying argillaceous bed of Tabata. It seems to me also quite reasonable that he has put together the fossils from these two beds in one and the same list, for these two beds are not palæontologically and stratigraphically quite distinguishable from each other.

Of the mollusca enumerated by Mr. Tokunaga, I have intentionally excluded *Potamides* cf. *incisus*, Hombr. & Jacq., as it seems identical with *P. fluviatilis*; I also think that *N. livescens* of the author (from Tabata, though not from Oji) is quite different from the species described by Philippi under that name. On the whole, there are known from Tabata twenty-six species of Gasteropoda and fifteen species of Pelecypoda (Lamellibranchia), of which the following twelve are especially abundant: *Nassa livescens*, *Potamides zonale*, *P. fluviatilis*, *Rissoa cerithina*, *R. septentrionalis*, *Ringicula arctata*, *Martesia striata*, *Saxicava arctica*, *Tellina yedoensis*, *Macoma nasuta*, *Cyclina chinensis*, and *Arca granosa*.

Mr. Tokunaga was of opinion that the shell-beds of Oji, Tabata, and Shinagawa were all of marine origin and of similar facies (loc. cit., p. 77, footnote). This seems to me decidedly untenable, because the shell-bed of Tabata is obviously a typical estuarine deposit according to the previously recorded molluscs, which are in association with abundant remains of land-plants, and from the lithological character of the sediments; while those of Oji and Shinagawa are deposits from a somewhat deeper, normally saline water, more distant from the coast. Especially in the shell-bed of Shinagawa, we find abundant Foraminifera and Ostracoda, both including typical plankton forms. At any rate it seems certain that these three localities were at that time in one and the same inlet of the sea, which was sheltered and quite free from the action of breakers.

Of an essentially different nature from the estuarine formation is the shell-sand exposed at a distance of 200 metres, in the section at Tabata. From the stratigraphical evidence it is quite certain that the shell-sand is on the same level as the brown and blue clay of the other section, and consequently represents a little higher horizon than the principal shell-bed of Oji and Shinagawa. Mr. Yamakawa collected and determined in the recently found shell-sand the following mollusca:—

Mollusca from the Shell-sand at Tabata.

Gasteropoda.

Volutharpa perryi, Jay.
Nassa japonica, Adams.
Pleurotoma reciproca, Gld.
P. cf. *gracilenta*, Rve.
Natica clausa, Desh.
Odostomia planata, Gld.
Leptothyra sp.
Ringicula arctata, Gld.

Lamellibranchia (or Pelecypoda).

Solen krusensterni, Schrenk.
Machæra pulchella, Dkr.
Panopæa generosa, Gld.
Corbula sp.
Myodora fluctuosa, Gld.
Mactra sachalinensis, Schrenk.
M. sulcataria, Desh.
Ræta yokohamense, Pilsb.
Tresus nuttalli, Conrad.
Tellina venulosa, Schrenk.
T. nitidula, Dkr.
T. nipponica, Tok.
Saxidomus nuttalli, Conrad.
Venus stimpsoni, Gld.
Dosinia exoleta, L.

Tapes sp.
Cardium braunsi, Tok.
C. californiense, Desh.
Phacoides aff. *borealis*, L.
Diplodonta pacifica, Tok.
Nucula insignis, Gld.
Yoldia sp.
Arca tenuis, Tok.
Pectunculus albolineatus, Lischke.
Pecten tokyoensis, Tok.
P. laqueatus, Sowb.

Of these eight species of Gasteropoda and twenty-six species of Lamellibranchia (Pelecypoda), *Natica clausa*, *Panopæa generosa*, *Tellina venulosa*, *Saxidomus nuttalli*, *Venus stimpsoni*, *Arca tenuis*, and *Pectunculus albolineatus* are predominant, whereas *Solen krusensterni*, *Mactra sulcataria*, *Tresus nuttalli*, *Tellina nipponica*, *Diplodonta pacifica*, and *Pecten tokyoensis* are very common.

The comparison of these two lists of fossils shows that only four species—*Nassa japonica*, *Ringicula arctata*, *Solen krusensterni*, and *Tellina yedoensis*—are common to both; whilst the complete absence of the typical estuarine forms is a distinguishing feature of the newly found molluscan fauna. The number of the common species may perhaps be somewhat increased by more extensive and cautious collecting of fossils from both localities; but the striking difference of these two faunas seems to be quite apparent.

On the other hand, the new fauna from Tabata has nearly all the species in common with the fauna from the principal shell-bed of Oji and Shinagawa, which decidedly represents a slightly lower horizon, as mentioned above; the only exception is *Tellina venulosa*, which is so abundant in Tabata, but still unknown from other fossiliferous localities in and near Tokyo. This difference is more remarkable when we take the fact into consideration that this species, now living in great abundance in the surrounding seas of Hokkaido, and rarely found in a diminutive form along the more southern coasts washed by the cold Lyman current, is found in multitudes in the shell-sand of the Narita Series, which is extensively developed in the province of Shimosa and in the part of Musashi lying east of Tokyo. The shell-sand of the Narita Series is considered by Tokunaga to be younger than the shell-beds of Tokyo, taking together the shell-beds of Shinagawa, Oji, and Tabata, while others think them of nearly the same age.

It is necessary here to introduce a short account of the Narita Series from one of my former articles in Japanese, supplemented by later observations.

In the extensive tract of loam, lying east of Tokyo, is a subaerial deposit, without any trace of stratification and sometimes with thin irregular layers of nearly decomposed pumice, is underlaid by a thick complex of marine sand with a little intercalation of clay and argillaceous sand which for convenience sake I called "Narita Series", from the reason of its typical development in the neighbourhood of Narita in the province of Shimosa. The marine sand is sometimes very fine-grained and sometimes coarse, even mixed with shingle, composed chiefly of quartz fragments, and in great contrast to the shell-bearing sand of Tokyo; it is not tufaceous. Cross-bedding is universal. The distribution of fossil shells in the sand is not uniform, but they are found here and there in considerable numbers.

The fossil contents of the Narita Series are almost exclusively confined to Mollusca and a species of Echinoderm, although naturally other fossils, for example, Foraminifera, Corals, and Crustacea, are not excluded, being relatively so seldom met with that they may be considered of no practical value for classification of the beds. Of the Mollusca the great majority belong to the Lamellibranchia (or Pelecypoda), which much exceed the Gasteropoda in number of species as well as in quantity of individuals. The molluscan fauna of the "Narita Series" is equal in number of species to that of the shell-beds of Shinagawa and Oji; but a striking feature of the former is the exceeding preponderance of certain forms over others, the most conspicuous species being *Mactra sulcataria*, *Tapes philippinarum*, *Tellina venulosa*, *Solen krusensterni*, *Diplodonta pacifica*, and *Pectunculus albolineatus*; *Echinorachnius mirabilis* belongs also to the same category, and in some localities it is found almost alone and without the presence of other fossils.

Another characteristic feature of the fossiliferous bed in a typical development is its contents of triturated shell-fragments in great quantity, beside its mineral composition, so that the term shell-sand seems really appropriate. The shell-remains vary in preservation and are generally very water-worn; the Pelecypoda are seldom found with both valves associated. The formation of the fossiliferous bed might have originated just in the same way as obtains at present along an ocean coast exposed to the violent abrading action of mighty waves. The shell-bearing sand of Oji and Shinagawa was formed in a different way; the Pelecypoda are often found with both valves connected and in the position which they assumed during the living state, and there are besides numerous vertical sand or clay-tubes not in the least distorted; such conditions would tend to prove that sedimentation took place in quite calm water.

Stratigraphically the Narita Series, at least in its upper part, is decidedly younger than the shell-beds of Shinagawa and Oji, but whether its lower part is not synchronous with the latter is at present questionable; the faunal difference seems in this case to depend more upon the geographical separation and the difference of the physical conditions of the places where the marine sediments were deposited than on the slight difference of age. The question of the relative geological age of these two faunas is only to be decided by means of a boring at a proper place in the district of the Narita Series, unless the typical Oji fauna is found beneath the shell-sand of the Narita Series.

The sandy gravel bed between the loam and the brown and blue clay of Tabata is considered by me as a special development of the Narita Series, or at least of its upper part; the sandy gravel bed passes on one side into an immense accumulation of gravels of various sizes, and on the other side to fine sand with cross-bedding; fossils are very seldom found in it, but I can safely conclude from material at my disposal[1] that the formation of the deposit is either marine or coastal, at all events so far as the deposit in Tokyo is concerned.

[1] Professor B. Koto and I have collected in the sandy gravel bed of Shibuya (in Tokyo) *Neptunea despecta* and *Cancellaria nodulifera*.

This consideration finds support in the evidence afforded by the shell-sand exposed beneath the sandy gravel bed in the cutting of the Yamanota line at Tabata; it has already been pointed out that the fossil remains from the shell-sand exhibit a certain resemblance to the Narita fauna. As it is found quite isolated in the district in which the Oji fauna occurs—I mean by this the molluscan fauna of the principal shell-bed of Oji and Shinagawa—it is of course not in the typical development of the Narita fauna as would reasonably be expected, but on the contrary it shows a partial similarity to the Oji fauna, as indicated by the absence of *Echinorachnius mirabilis* and *Tapes* aff. *philippinarum* and by the frequency of *Pecten tokyoensis*; the two former species are very abundant in the typical shell-sand of the Narita Series and very seldom found in the Oji fauna, whilst the latter bears quite a reverse relationship. Briefly, the new Tabata fauna seems to show the characteristic features of the Oji and Narita faunas in combination, which have hitherto been found geographically quite separate from each other. This indicates that the life assemblage belongs to a transitional type between the Oji and Narita fauna in regard to both geological and geographical distribution.

About the subdivision of the Diluvial deposits (including Pliocene?) in Tokyo and their correlation with the European standard, various propositions have been made, among others, by Messrs. Brauns, T. Suzuki, and Tokunaga. Professor Brauns,[1] who identified many of the molluscs from the shell-bed of Oji and Shinagawa with the English Crag forms, claimed the shell-bed to be of Pliocene age, and considered the wavy surface of the shell-bed as indicating a significant stratigraphical gap between this and the overlying bed. As a consequence, he adopted the following subdivisions: (1) Upper Diluvium—loam; (2) Lower Diluvium—sandy gravel beds with an intercalating clay-bed; (3) Pliocene—shell-bed of Oji and Shinagawa and the underlying gravel and sand beds. Mr. Suzuki[2] differed from Brauns in regarding the clay and sand beds overlying the shell-bed as Pliocene, while Mr. Tokunaga, in his detailed study of the fossils, was of opinion that the shell-bed of Oji and Shinagawa as well as the overlying sand and clay beds, yielding many fossils at Tabata as mentioned before, must be of Pleistocene age; he considered these beds as forming altogether a complex, but without referring to its relation with the covering sandy gravel bed.

My personal observation about the question led me to conclude that the statement of Brauns regarding the loam and the underlying rock series is correct, but about the other line of boundary Suzuki and Tokunaga's opinions are to be preferred.

I have already often used the name Narita Series for the complex underlying the loam and chiefly composed of sand and gravel beds with some intercalation of thin clay layers at various horizons; for the lowest complex I now wish to propose the name Tokyo Series; the latter consequently includes the principal shell-bed of Oji and

[1] "Geology of the Environs of Tokio": Mem. Sci. Dept. Tokio (University), 1881, No. 4, p. 77.

[2] Explanatory Text to the Geological Sheet, Tokyo, 1887 (issued by Geol. Surv. Japan).

Shinagawa with the Oji fauna and the estuarine shell and plant beds of Tabata. This proposal is made partly for the purpose of avoiding the undesirable method of employing such vague terms as Pliocene or Pleistocene for the beds of Oji, etc. There is no doubt that Professor Brauns was mistaken in claiming the Oji fauna to be of Pliocene age, as also was Mr. Suzuki for the estuarine bed; on the other hand, the statement of Mr. Tokunaga favouring the Diluvial age of the Tokyo Series is in part quite correct.[1] Mr. Tokunaga had determined ten extinct species and 155 species belonging to modern forms; the percentage of extinct species to the living is too small to assume the series to be of Pliocene age. It is, however, not quite clear how far the application of the European standard of ratio between the living and extinct molluscan species can be relied upon for the correlation of the geological age of a certain late Cainozoic formation in Japan, especially in so widely distant a part of the world.

The Diluvial age of the series now under consideration appears to be further supported by additional evidence, afforded by the presence of molar teeth of *Elephas antiquus*, Falc., which it seems have been obtained from the estuarine clay-bed of Tabata. It must also be taken into consideration that the Kendang or Trinil Beds of Trinil, Java, with abundant mammalian remains, are still under dispute as to their geological position; the question being whether the complex is of Pliocene or Pleistocene age. In the present case more uncertainty exists because it is somewhat doubtful whether the molar teeth were found in the topmost bed of the Tokyo Series or whether they were obtained from the overlying sand-bed of the Narita Series.

But practically it is insignificant whether the Tokyo Series is of Pliocence or Pleistocene age, the constitution and general facies of the fauna being now fully known to us by the detailed study of Mr. Tokunaga; one of his conclusions, however, must be considered with great caution, viz. that the sea near Tokyo was inhabited at that time by molluscs of a climate colder than that which now prevails. This generalization is quite untenable, but it is possible that the relative influence of the cold and warm currents alone, which have followed nearly the same course since Jurassic times, when the Behring Strait was opened or any other similar water communication existed between the Polar seas and the North Pacific Ocean, and without any other essential climatic change in reality may have produced the same effect on the marine organisms living in a shallow inlet of the sea as once existed in the region where Tokyo now stands.

Such unconformity in deposition is not unfrequent in estuarine and strand formations, and must not be taken as an indication of an important stratigraphical gap between two successive formations. Professor Brauns also paid early attention to the existence of such unconformity in our diluvial deposits and explained likewise its stratigraphical insignificance; he was only misled by the wavy surface of the shell-bed of Oji and Shinagawa, which he took as

[1] He enumerated *Diplodonta pacifica* among the extinct species; but it is found living in the surrounding seas of Hokkaido and also, though more seldom, along the east coast of Honshyu (main island of Japan).

the boundary between the Pleistocene and Pliocene deposits. This error was soon afterwards justly corrected by Suzuki and later more effectually by Tokunaga.

Of more importance to the discussion is the boundary between the Narita and Tokyo Series, which was once exposed very favourably in the sand ditches along the Owu line at Tabata. The marked difference of lithological characters between the two consecutive beds above and below the boundary-line made the unconformity very striking.

At that time I was inclined to take it as an evidence of time-interval between two deposits; the new discovery of the shell-sand, which is the main subject of the present article, however, entirely deprived me of any confidence in this previous supposition. As mentioned above, we see now at Tabata, on one side the regular downward succession of sandy gravel bed and sand-bed which locally passes to argillaceous sand, arenaceous clay, and the shell-sand with the characteristic transitional fauna between the Oji and Narita fauna, and on the other hand likewise quite a regular succession of the deposits of the Tokyo Series, namely, in ascending order (A) the principal shell-bed of Oji and Shinagawa, (B) sand and clay beds of an estuarine formation. These estuarine deposits of the Tokyo Series lie on the same level as, and in close proximity to, the sand-bed which is the direct continuation of the shell-sand above mentioned. The detailed local researches of Mr. Yamakawa and myself have clearly revealed the total absence of any indication of a stratigraphical break between them. We are therefore obliged to conclude that the variation of sediments is only a local phenomenon and that their deposition took place side by side at the same time. Consequently, the apparent unconformity between the Narita and Tokyo Series must also be regarded as only of minor geological importance.

NOTICES OF MEMOIRS.

On the Value of the Fossil Floras of the Arctic Regions as Evidence of Geological Climates.[1]

By Professor A. G. Nathorst, Hon. Sc.D. Camb., of Stockholm.

Translated from the French original[2] by E. A. Newell Arber, M.A., F.G.S.

AMONG the problems which are constantly called to mind during geological explorations in the Arctic regions, that of the climates of the past naturally demands special attention. The contrast between the present and the past is there more striking than in any other region. Beneath the snow and ice bordering the Arctic sea, one marvels to find, for example, large corals in beds belonging to the

[1] A paper read before the Eleventh International Geological Congress on August 25, 1910. "Sur la valeur des flores fossiles des régions arctiques comme preuve des climats géologiques," Stockholm, 1910. Also in Compt. Rend. Eleventh Intern. Geol. Congr., Stockholm, 1911.

[2] The English translation has been revised by Professor Nathorst, and references added.

Carboniferous System, or again the remains of Saurians, Ammonites, or Nautiloids, in those of Triassic age. But when one bears in mind the extreme richness of the Invertebrate fauna of the Arctic seas to-day, when one remembers the colossal whales which find their subsistence in these waters, one may be inclined to ask if it has not been an error to conclude, from the occurrence of the fossils above mentioned, that the climate was formerly more genial than it is to-day. Should we not be under-estimating the creative power of life if we imagine that, among the Saurians, the Ammonites, and the Nautiloids, no species has been able to develop which was adapted to life in the Arctic seas? If the Reindeer and the Musk-ox were extinct, who would imagine that these beasts were able to flourish on the scanty vegetation of the high parallels north of 80° of latitude? And who would suppose that such monsters as the Mammoth and the Woolly Rhinoceros could find sufficient nourishment in the poor vegetation of the Tundras or the Coniferous forests? Such examples teach prudence; there is certainly no question which requires so much caution as the problem of deducing from the faunas of the past the climatic conditions under which they flourished.

This remark applies with equal force to the floras. Although to-day the Cycads only occur in warm regions, it would be an error to conclude that the Cycadophyta of the past have always flourished under similar conditions. On the contrary, we must admit that during the Mesozoic period, when these plants were abundant, it would no doubt have been possible to find several species which had adapted themselves to an Alpine climate if such a one had then existed. And if, since then, the differentiation of climates has begun to make itself felt, it would be again a case of overlooking the creative power of life, if we assumed that none of the species of Cycadophytes were able to adapt themselves to a temperate climate in the Polar regions. Again we meet with difficulties, even when we study the plants of the Tertiary period, which are assigned to genera still living. Our Common Juniper (*Juniperus communis*, Linn.), which exists in Northern Europe as far north as the North Cape, exceeds by 20 to 25 degrees of latitude, in the Eastern Hemisphere, the northern limit, not only of the other species of the genus, but also the whole family of the Cupressineæ. Now, if one imagined that the Common Juniper was extinct, one would naturally draw conclusions relative to the fossil remains from the distribution of the other species. And one would consequently suppose that it lived under a climate much warmer than is actually the case. One would scarcely imagine that we were concerned with a plant adapted not only to temperate, but also to Arctic, climates. (One finds the Juniper, on the western side of Greenland, up to the 64th parallel.)

These examples counsel prudence, and the matter should be treated with judgment and circumspection. But, even if it is necessary to make reservations, when one seeks to determine from the fossil plants the nature of former climates in the Arctic regions, at least one cannot doubt that they were distinctly warmer than that of the present day. The difficulty of explaining these former climates, especially when one has to take into consideration the length of the winter night, is without doubt the reason which has led some scientists to evade the question, instead of seeking to solve it. It is indeed a case of evading the question when it is boldly asserted that the plant-remains, on which Heer[1] has based his theories of ancient Arctic climates, have been drifted by marine currents to the places where they have been found.

It is not to be disputed that plant debris may be transported in water for a very great distance without being damaged, provided that they are carried at a sufficient depth to escape the influence of the movements of the surface layers of the water. When Agassiz was engaged in dredging on the American coasts, he found that the bottom of the sea—sometimes to a depth of nearly 3,000 metres—was covered with plant debris, such as wood, branches, leaves, seeds, and fruits, in all stages of decay. Also, in certain places, these remains were still fairly abundant at a distance of 1,100 – 1,200 kilometres from the shore. This distance corresponds to about 10 degrees of latitude. It is thus proved that the remains of plants may be transported for very considerable distances. But this is true only of marine deposits. If we are concerned with freshwater sediments, the example given has no bearing on the case.

One might, however, reasonably suppose that a river, flowing in the direction of the meridian from south to north, might have carried from the southern regions leaves and other fragments of vegetation which became buried in some deposit of the stream itself, or of a lake, which it traversed, or of its delta. This is a possibility which must not be neglected, but on the other hand it must not be treated as though it were an ascertained fact, since we do not know how far it applies to the case in point.

The fact is, it is puerile to attempt to draw conclusions as to the ancient climates of the Arctic regions, before the nature of the deposits in which the fossil plants have been found has been ascertained. It is especially important that an attempt should be made to answer the question, did the plants once flourish in the neighbourhood of the deposits in which they are found, or were they transported from far-away lands? It is this question which an attempt will here be made to solve, by furnishing a concise résumé of the principal beds containing fossil plants in the Arctic regions.

In Bear Island,[2] and in Ellesmere Land,[3] beds extremely rich in plant-remains are met with belonging to the Devonian system. The fossil plants of Bear Island occur in the series of beds which also include several seams of coal. Beneath the coal, which is composed essentially of the bark and trunks of *Bothrodendron*, one finds, as elsewhere, bituminous schists containing roots, and from this one can show that the plants of which we speak flourished, at least in part, in situ. This is likewise proved by the actual nature of the plants, as much in the older beds with *Archæopteris fimbriata*, Nath.,

[1] O. Heer, *Flora fossilis arctica*, vols. i–vii, 1868–83.
[2] A. G. Nathorst, "Zur Oberdevonischen Flora der Bären Insel": Kongl. Svenska Vet.-Akad. Handl., vol. xxxi, No. 3, 1902.
[3] Id., "Die Oberdevonische Flora des Ellesmere Landes": Rep. 2nd Norweg. Arctic Exped. in the Fram, vol. i; Christiania, 1904.

as in the more recent with *Pseudobornia ursina*, Nath. The latter species has been found with large stems or rhizomes, as well as very small ones, only a few millimetres in diameter, to which extremely delicate, almost membranous, leaves are still attached. It is hence quite certain that there is here no question of the plants having come from distant regions. The materials have not been sorted out. One sees a medley of branches, small and large, and the perfection of the preservation of their delicate leaves demonstrate conclusively that they have not undergone transportation from afar. The same applies to *Archæopteris fimbriata.* The beds of coal, the clay with rootlets, and the very nature of the plants themselves, all point to the same conclusion, namely, that we have here a flora which flourished in part on the very spot where it is now found.

As I have already pointed out in my description of the Devonian flora of Ellesmere Land, one arrives at the same conclusions here also, and it is unnecessary to enter into further details.

In the Arctic regions, Culm deposits, yielding fossil plants, are known from Spitzbergen,[1] from the north-east of Greenland,[2] and probably from the south of Melville Island, in the Arctic Archipelago of America.

We will here concern ourselves only with Spitzbergen, although it may be mentioned in passing that the flora of the Culm discovered by the Danish expedition in North-East Greenland, in latitude 81° North, consists of nearly the same species as that of Spitzbergen. The latter flora has been observed in many localities up to 79° of latitude. It is characterized by the presence of *Stigmaria*, with appendicular organs radiating in all directions, still in continuity and penetrating the clay beneath. We are thus able, in several places, to observe the presence of *Stigmaria* in situ, which furnishes undeniable evidence of the fact that the plants lived in the place where we now find them. The stems of *Lepidodendron* found in the same place have a diameter of at least 40 cm. It would be superfluous to give other examples, for one can scarcely doubt that the plants of the Culm have flourished in the very place in which they are now found, or in its vicinity.

On the other hand, the observations which relate to the Triassic plants of Spitzbergen and Eastern Greenland are somewhat different. The latter ones belong to the Rhætic Series and include several species of *Pterophyllum*, *Podozamites*, *Cladophlebis*,[3] etc. In Spitzbergen one finds them as far north as 78°.[4] Neither there nor in Eastern Greenland, where one meets with them between the 70th and 71st parallel, are they associated with beds of coal, but the manner in which they occur in Greenland indicates that in no case have they

[1] A. G. Nathorst, "Zur Paläozoischen Flora der Arctischen Zone": Kongl. Svenska Vet.-Akad. Handl., vol. xxvi, No. 4, 1894.

[2] Id., "Contributions to the Carboniferous Flora of North - Eastern Greenland": Meddelelser om Grönland, vol. lxiii; Copenhagen, 1911.

[3] N. Hartz, "Planteforsteninger fra Cap Stewart i Östgronland": Meddelelser om Grönland, vol. xix; Copenhagen, 1896.

[4] A. G. Nathorst, "Zur Mesozoischen Flora Spitzbergens": Kongl. Svenska Vet.-Akad. Handl., vol. xxx, No. 1; Stockholm, 1897.

travelled from very distant localities. One has not with certainty observed any marine petrifactions associated with the plants, but it has not yet been clearly determined whether the Triassic beds with fossil plants of Spitzbergen are of marine or of freshwater origin.

The most ancient Jurassic sediments of Spitzbergen are marine, and belong to the Sequanian stage. There was consequently a long interruption in sedimentation after the formation of the Rhætic beds.[1] The upper part of the Jurassic formation (Portlandian) furnishes a series of plant-bearing sandstones, seams of coal, and beds of undoubted freshwater origin, containing *Unio* and *Lioplax polaris*. The fossil plant-remains belong to two different floras, one, the more ancient, being characterized by the presence of *Ginkgo digitata*, Brongn., sp.; the other, the more recent, by *Elatides curvifolia*, Dkr., sp. The two floras are associated with beds of coal, and one may here also put forward the view that the plants originally flourished in the place where they are now found. One of the coal-seams at Cape Boheman furnishes a great abundance of *Podozamites* and *Pityophyllum*; sometimes the surface of the schists is as completely covered with the leaves of *Ginkgo digitata*, as the soil beneath a living *Ginkgo* tree may be in autumn. Since branches and seeds of the same plant are also associated, it is natural to suppose that a Ginkgo forest occurred not far away from this spot. The same observation applies to *Elatides curvifolia* of the more recent flora, which occurs locally in the freshwater beds containing *Unio* and *Lioplax*. Floras of the same age and composition are also known from King Karl's Land, the islands of New Siberia,[2] from Northern Siberia, and Arctic Alaska.

The Neocomian Series of King Karl's Land is overlain by sheets of basalt, often amygdaloidal, and containing chalcedony and agates. Fragments of silicified woods, large and small, also occur here, and these, without doubt, owe their mineralization to the volcanic phenomena. Some of these trunks are fairly large, and I have myself measured one, which, although incomplete, was 70–80 cm. in diameter, and showed 210 annular rings. Some of these remains consist of the lower portion of the trunk and the primary ramifications of the roots.

The microscopic examination of these specimens, undertaken by Dr. W. Gothan,[3] has shown that the annual rings of the fossil stems from King Karl's Land were much more accentuated than those of stems found in the corresponding beds of the European continent, which indicates that the trees lived in a region where the difference between the seasons was extremely pronounced. They cannot therefore have been transported from the south by marine currents, and as the trunks found in the corresponding beds of Spitzbergen[4] show the

[1] A. G. Nathorst, "Beiträge zur Geologie der Bären Insel, Spitzbergens, und des König Karl Landes": Bull. Geol. Inst. Upsala, vol. x, 1910.

[2] Id., "Über Trias und Jurapflanzen von der Insel Kotelny": Mém. Akad. Imp. Sci. St. Pétersbourg, ser. VIII, vol. xxi, No. 2, 1907.

[3] W. Gothan, "Die fossilen Hölzer von König Karls Land": Kongl. Svenska Vet.-Akad. Handl., vol. xlii, No. 10, 1907.

[4] Id., "Die fossilen Holzreste von Spitzbergen": Kongl. Svenska Vet.-Akad. Handl., vol. xlv, No. 8, 1910.

same peculiarity, it is quite safe to conclude that we are here concerned with large trees, which have actually flourished in these latitudes, and which have not been transported from more southern regions.[1]

The Cretaceous System, as we know it, is represented in Western Greenland, between the parallels of 69° and 71°, by an important series of beds containing fossil plants belonging to the Urgonian, Cenomanian, and Senonian, the two first mentioned containing coal-seams. I have been able to show, as the result of the studies which I made in Greenland in 1883, that beds, full of roots, underlie those containing fossil plants at Unartoarsuk, as well as at Igdlokunguak. Without doubt the Urgonian flora, like the Cenomanian flora, is a relic of vegetation which once flourished in the same regions where we now find the fossils. But, on the contrary, the Senonian flora, or flora of Patoot, is in part contained in marine beds, containing *Inoceramus*, etc., and thus it may have been transported from some distance. The Urgonian flora, or flora of Kome, is composed of Ferns, Cycadophytes, and Conifers, while the Cenomanian or Atane flora, in addition to arborescent Ferns (*Dicksonia*) and Cycadophytes (*Pseudocycas*),[2] is particularly rich in the leaves of Dicotyledonous trees, among which are found those of planes, tulip-trees, and bread fruits, the last mentioned closely resembling those of the bread fruit-tree (*Artocarpus incisa*)[3] of the islands of the Southern seas.

In the limited space at my disposal, I have had to be content with a brief summary of the strata containing fossil floras of Palæozoic and Mesozoic age. But, from what has been said, it is clear that we have every reason to regard the floras of the Devonian, Culm, Jurassic, and Cretaceous of the Arctic regions as being composed of plants which flourished in these very regions. It has not been definitely proved that the Triassic flora has been transported from more Southern regions by marine currents, but there is still some uncertainty on this point.

In relation to the present problems, the Tertiary floras are undoubtedly the most important, and for this reason I will enter into the subject in some detail. But the materials are so wonderfully rich

[1] It may be mentioned here that a silicified *Dadoxylon* from the Carboniferous deposits of Spitzbergen described by Dr. Gothan (loc. cit.) does not show any annual rings at all, precisely as is the case with the corresponding Palæozoic stems of Europe. As observed to me by Mr. Th. Halle, this is a most curious circumstance, since the darkness during the long winter night in those regions—provided that the position of the North Pole was the same as now—ought to have caused an interruption of the growth, even if the climate was a warm and genial one. As the specimen, however, was not found in situ it is possible that it originates from some marine deposit into which the wood had been brought by ocean currents from more southern latitudes. But also a *Dadoxylon* from the Triassic of Spitzbergen shows only slight indications of annual rings (Gothan, loc. cit.).

[2] A. G. Nathorst, "Paläobotanische Mitteilungen, 1 und 2. *Pseudocycas*, eine neue Cycadophytengattung aus den Cenomanen Kreideablagerungen Grönlands": Kongl. Svenska Vet.-Akad. Handl., vol. lxii, No. 5, 1907.

[3] Id., "Über die Reste eines Brotfruchtbaumes, *Artocarpus Dicksoni*, n.sp., aus den Cenomanen Kreideablagerungen Grönlands": Kongl. Svenska Vet.-Akad. Handl., vol. xxiv, No. 1, 1890.

that I shall have to restrict myself to giving some examples indicating the nature of the beds containing the Tertiary plants in Spitzbergen, Iceland, and Greenland. More especially, I shall recall that they are found at 79° of North latitude in Spitzbergen; on the east coast of Greenland between 74° and 75°, and on the west coast between 69° and 73°; at Lady Franklin Bay, in Grinnell Land (81° 42′); in Ellesmere Land between 77° and 78°; on the River Mackenzie at 65°; in Alaska south of 60° (and therefore outside the Polar Circle); and lastly in the islands of New Siberia (75°). Iceland, it is true, is outside the Polar Circle, but nevertheless its Tertiary flora may be included in this consideration.

The Tertiary formations of Spitzbergen, which have a thickness of perhaps 1,200 metres or thereabouts, contain fossil plants and seams of coal, both in the upper and lower beds, though the middle portion is marine. As an example of the deposits with fossil plants from the base of this formation the shales called the 'Taxodium Shales', at Cape Staratschin, may be mentioned. These are fine-grained black soft shales, which form the roof of a small bed of coal. In the shales the leafy branches, the flowers, the seeds, and the ovuliferous scales of the Swamp Cypress (*Taxodium distichum miocenum*), the leafy branches of *Sequoia Nordenskiöldi*, Hr., and *Librocedrus Sabiniana*, Hr., are particularly common. There are also associated a large number of remains of Gramineæ, Cyperaceæ, several species of Pines and Firs, a *Potamogeton*, and the leaves of various Dicotyledonous trees. Thus, as Heer has shown, one is dealing here with freshwater sediments, in the neighbourhood of which it is evident that the Swamp Cypresses have formed forests, as in the swamps in the southern portion of the United States to-day. This conclusion is also confirmed by the occurrence of the remains of rather numerous insects, among which there are a score of Coleopterids, two of which are hydrophilous Coleopterids (*Hydrobius* and *Laccophilus*).

These beds with fossil plants, at the base of the Tertiary formations of Spitzbergen, are overlain by thick marine sediments. In their upper portion, the latter show indications of a retreat of the ocean and a recurrence of freshwater conditions. It is possible that the leaves found in the lower part of the higher horizon containing fossil plants have been transported from afar by a river, and deposited near its mouth, but as regards the upper portion, deposition must have taken place in vast swamps, on which the majority of the plants actually lived. In these beds one notices thin seams of coal, a great quantity of leafy branches, and also cones of *Sequoia Langsdorfii*, Brongn. (which resembles the Red Wood of California, *Sequoia sempervirens*, Endl.) and the Swamp Cypress (*Taxodium distichum miocenum*). Here and there a large Horsetail (*Equisetites Nordenskiöldi*, Nath.) occurs in such abundance that one would imagine that it formed small forests. There are also associated rhizomes, with their roots and tubercles still attached. I may mention in passing that *Equisetum arcticum*, Heer, occurs in the same manner in the lower zone of the plant-bearing beds. There also occurs a great abundance of *Osmunda spitzbergensis*, Nath., and on the same horizon nodules of clay ironstone, entirely filled with leaves and stems of the latter plant, in which the tissues have been so completely mineralized that one can study the microscopic structure as minutely as in the living *Osmunda*. One sees in the carbonaceous petrified layers rootlets and spores of ferns, as well as fragments of branches, etc. This might justly be called a mineralized peat. Among the Dicotyledonous trees, the leaves of which occur in great quantity, one finds leaves of all dimensions belonging to the more common species. I have examples, among others, of the leaves of *Ulmiphyllum asperrimum*, Nath., varying from 1–17 cm. in length. All the observations indicate that we have here a deposit formed by the delta of a stream, passing through a marsh, on which grew trees requiring humidity, while the remains of other plants which lived at some distance away have been transported, either by the wind or by water, and become mingled with those of the marsh.

The beds of this horizon, discovered at Cape Lyell, are remarkable for the enormous quantity of leafy branches of *Sequoia Langsdorfii*, leaves of *Grewia crenata*, Hr., and of *Acer arcticum*, Hr., the fruits of the last mentioned also occurring. A bed full of rootlets was also met with, showing that the plants flourished on the spot where they are now found. Among the marsh plants an *Alisma* occurs. Among the Dicotyledonous trees of this horizon are Poplars (*Populus*), Willows (*Salix*), Alders (*Alnus*), Birches (*Betula*), Hornbeams (*Carpinus*), Hazels (*Corylus*), Beeches (*Fagus*), Oaks (*Quercus*), Elms (*Ulmus*), Planes (*Platanus*), Magnolias (*Magnolia*), Limes (*Tilea*), and Maples (*Acer*), etc. We can thus show that during the Tertiary period all these plants have flourished at 78° or 79° of latitude. In Grinnell Land we find, even at nearly 82°, the Swamp Cypresses, the Spruces, Pines, Firs, Poplars, Birches, Elms, Limes, etc.

In Iceland the Tertiary flora may be studied in the volcanic tuffs or in the alluvium formed from them, and at Brjàmslaekur, for instance, in a deposit which may be compared with a laminated peat. Thus, as Heer had suggested, and Thoroddsen has proved, we here meet with formations laid down above sea-level, which are overlain by thick basaltic beds. A glance at the specimens from Brjàmslaekur serves to show that we have here to deal with freshwater deposits. M. Östrup's[1] microscopic examination of the Diatoms, found in the same beds as the fossil plants, confirms this conclusion, for they are freshwater species.

Among the beds furnishing Tertiary plants, so abundant in Greenland, I will only mention that at Harön, near Waigattet. Here the plants occur either in a true basaltic tuff or in an altered tufa or a sediment formed from it, and overlain with basalts.

The investigation of two beds, which I made in 1883, has proved that they cannot be other than formations laid down above sea-level. In one of these deposits the fossil flora consisted almost exclusively of leaves of the Maple (*Acer*), crowded like those which cover the ground in autumn, and among these leaves large samaras, like those of

[1] E. Östrup, "Diatoméerne i nogle islandske Surtarbrandlag," pt. i: Meddel. fra Dansk Geol. Forening, No. 3; Copenhagen, 1896. Pt. ii, ibid., No. 6, 1900.

A. otopteryx, Gp., occur. In another bed the tuff was formed of cinders and small lapilli, and the way in which the vegetable fragments were embedded leads one to suppose that the branches, leaves, and fruits of the trees were broken off by a shower of cinders and lapilli. A medley of silicified branches of different sizes occurs, and among them are the cones of the Spruce, the nuts of the Walnut (*Juglans*), and the Hickory (*Carya*), with the leaves of *Ginkgo*, etc. In the finer tuffs we likewise find the leaves of the Walnut, the leaves and fruits of an Ash (*Fraxinus macrophylla*, Hr.), and the leaves of species common in the Tertiary flora of Greenland, such as the Plane, Oak, Chestnut, Beech, etc.

The presence of the leaves of *Potamogeton*, associated with a freshwater mussel (*Unio*), indicates that the deposits were of freshwater origin. Some of the branches of the trees are silicified and exhibit, under the microscope, an extremely well-preserved structure. M. J. Schuster, who has undertaken a preliminary examination of these remains, concludes that they all belong to one species, which was probably either an arborescent member of the Leguminoseæ or of the Rosaceæ. It is clear that we have here to deal with fragments of vegetation broken off by a shower of ashes and entombed in them, though some fragments may have been transported into a freshwater basin containing mussels and aquatic plants.

The Tertiary plants discovered by the Norwegian Expedition to Ellesmere Land deserve special mention on account of their state of preservation. They consist almost entirely of branches of *Sequoia Langsdorfii*, contained in a bituminous laminated clay, from which I have been able to remove them by a process of washing, with the result that they are now isolated like dried specimens in a herbarium.

I must here bring to a close my review of the ancient plant-bearing beds of the Arctic regions. We may conclude that, in the greater number of cases, it is evident that the plants really grew in the regions in question. Although we know of fossil plants in some marine deposits, as for instance in the Senonian of Greenland, and perhaps also in the Trias of Spitzbergen, these are exceptions which lack importance, since other deposits, of a closely corresponding age, are of freshwater origin. While it may be admitted that, even in Spitzbergen, part of the Tertiary flora may have been transported from a more or less distant country by a river, yet other deposits, on approximately the same horizon, indicate that the greater number of the species, and among them the most important types, have actually flourished in the region itself.

Taking into account the facts which I have enumerated, it is evident that the fossil floras of the Arctic should be still regarded as the foundation of every discussion of the former climates of this region. How are these favourable climates to be explained? That is a question to which we are not able to reply at the present moment, and of which the solution belongs to the future.

REVIEWS.

I.—The Geology of Water Supply. By Horace B. Woodward, F.R.S., F.G.S. 8vo; pp. xii, 340. London: Edward Arnold, 1910. Price 7*s.* 6*d.* net.

A HANDY book on Water and Water Supply has long been needed by the public; now, thanks to Dr. J. E. Marr, F.R.S., the editor of Mr. Arnold's Geological Series, the task has been undertaken by Mr. Horace B. Woodward, whose forty years connexion with the Geological Survey of England and Wales has given him long practical acquaintance with the principal water-bearing strata of our Island, while his advice has been frequently requisitioned by Government Commissions, by Water Companies, as well as by private persons, when seeking water, whether for camps, for cities, or for country residences.

It is not only essential for towns, for brewers, and many other manufacturers to obtain an abundant supply of water, but it must, in addition, be of good quality. There are cases upon record of deep borings having been undertaken by towns in order to obtain a large, constant, and pure supply of water, which have resulted satisfactorily both as regards quantity and constancy, but alas! the water proved too saline for drinking, and the cry of Coleridge's "Ancient Mariner" went up from that city of

> "Water, water everywhere,
> Nor any drop to drink"!

But that is only one of the evils to be guarded against by the engineer and chemist as well as the geologist in search of water. There is the fruitful and ever-present anxiety arising from the introduction of organic pollutions to which the water in every inhabited area is liable. Most suspicious or doubtful water which exhibits any proportion of such contamination has probably been derived from a shallow well or a river; but even deep wells or spring water are liable to contain at times some noxious germs through drainage percolation in the adjacent soil.

In rural districts (now happily rarely), the well for drinking-water and the cess-pit are sometimes to be found in dangerous proximity, and the very source of domestic water supply may thus become contaminated.

Going back to the original "sources of water supply, these depend almost wholly on rainfall, and the consequent springs, rivers, and lakes to which it gives birth, also on the geological structure which enables certain rocks to store large supplies of the rain that has percolated through the soil. As these factors are subject to extreme variation, so the problem of obtaining wholesome and adequate supplies may be either simple or fraught with great difficulty and uncertainty" (p. 2).

"Freshwater is required in all regions, from the tropics to the poles, and at different elevations, so that recourse must be had in some situations to the melting of snow or glacial ice, to natural water-holes, in arid regions, or to the sinking of wells along a dry river course, and to the distillation of sea-water, mostly on the ocean, but sometimes on the land" (as in some cities on the West Coast of South America).

"In primitive times, springs, brooks, rivers, pools, and lakes yielded the necessary supplies, and the earliest settlements were made in places where water could be thus freely obtained."

The digging of wells must have been amongst the very earliest achievements of mankind, as is evidenced by their frequent mention in the time of the patriarchs (Gen. xxvi, 15 and 18; Exod. xv, 27; Deut. vi, 11, etc.). A proverb of the East says—"To have digged a well, planted a tree, married a wife, and begotten a son are the evidences of a well-spent life." The Chinese, Babylonians, Egyptians, Greeks, Romans, and Moors have left ample testimony of their genius both in the sinking of wells and in the constructing of aqueducts. No doubt the engineer long antedated the geologist in all matters of water supply; but we must now always take the geologist into consideration when in search of drinking-water.

In these days in which science holds so large a share in all our undertakings, we cannot trust any longer to the 'water-finder' with his 'divining-rod'. As every child now expects to be told 'the why and wherefore in all things', it is not surprising to find men of experience looking askance at the diviner, with his forked hazel-twig or 'dowsing-rod', professing to show to the uninitiated, by some occult process, which he himself cannot explain, where and at what depth water may be found. It is interesting to know that the 'divining-rod' dates back to the earliest historic times, and was used for a variety of purposes, e.g., to prove the site of old landmarks, to detect crime, to guide the traveller in his right course, and moreover, the rod being attracted by all metals and in a certain order, it was employed in search of mineral lodes.

With the care and accuracy which always characterizes the author's work, Mr. Horace Woodward personally conducts his readers (of course umbrella in hand) through the water-bearing rocks and also through the non-water-bearing ones, explaining their disturbances and faults, their thicknesses, and other characteristics.

We are reminded how much of the rainfall is lost by evaporation, by absorption, by vegetation, and how porous beds take in the water, and what beds arrest its downward progress. And so we pass on to consider rivers, floods, and the drainage of land, of swallow-holes, pipes, springs, and river-courses, and what happens to our rivers when pumping is carried on upon a large scale to supply such thirsty souls as inhabit great cities like modern London. The economy of springs of all kinds is discussed and why some are constant and others not.

Wells next engage the reader's attention, and we discover that they are of many and various kinds, as 'dip-wells' by the roadside, and draw-wells worked by bucket and windlass, sometimes going to a depth of 160 feet. In some cases horizontal wells, or adits, are driven into the sides of hills to open up springs, or to tap the water-bearing strata below. Artesian wells and borings are also described, both flowing and non-flowing.

The water-bearing strata of England receive special attention, several chapters being devoted to their description. The quantity of water held in the chalk by capillary attraction is very remarkable. One square mile of dry upper chalk, one yard in thickness, contains nearly 3,500,000 gallons of water, and when saturated holds 200,000,000 gallons.

In the New Red Series we have a great thickness of water-bearing rocks. De Rance has recorded a well at Cardiff carried to a depth of 244 feet through red and green Keuper Marls which yielded a supply of 12,000 gallons per hour; and G. H. Morton records that twelve public wells, 4 miles from Liverpool Town Hall, gave an average daily yield amounting to 12,703,770 gallons. We note that much of the water from the Bunter Sandstone is hard (9° to 15°), and its hardness is said to increase with the age of the wells. But this hardness does not detract from its merit in the manufacture of Burton ales.

Prospecting for water nowadays, as described by the author, is by no means so simple a process as that recorded when Moses smote the rock twice with his rod and the water came out abundantly (Numbers xx, 11). Much care and geological knowledge now enter into the task, and maps and sections must be consulted; the dip or inclination of the beds and their thicknesses, the presence of faults, and the physical features of the ground have all to be taken into consideration. But we cannot follow the author step by step in his aquatic investigations, suffice it to say that forty-four well-chosen illustrations aptly aid the careful descriptions of earth-structures and clearly put before the reader all the salient points in water-geology, now a special branch of geological science. Happy is the present-day student who can enjoy all the advantages of Arnold's Geological Series as his guides and instructors, and who, whenever thirsty, can turn to Horace Woodward's abundant geological water supply, to obtain which no divination is required beyond a fee of 7*s.* 6*d.*

II.—Water Supply and Sanitation.

1. The Water Supply of Sussex from Underground Sources. (*Supplement.*) By William Whitaker, F.R.S.; with contributions by H. R. Mill, LL.D., and H. F. Parsons, M.D. London: printed for H.M. Stationery Office, and sold by E. Stanford, Long Acre, and T. Fisher Unwin, Adelphi Terrace. 8vo; pp. viii and 125 to 255. With Rainfall Map. 1911. Price 2*s.* 6*d.*

TWELVE years have elapsed since the publication of the original Memoir on the Water Supply of Sussex by Mr. Whitaker and Mr. Clement Reid. The Supplement is paged continuously with that work, and contains a general index to its full contents; and although the Supplement is longer by seven pages than the former memoir, and has in addition a colour-printed rainfall map, the price is less by 6*d.*

In his introductory remarks, Mr. Whitaker calls attention to the more noteworthy wells of Sussex and the supplies of water yielded by them. Deep borings seem generally to add to the estimated thickness of formations, as in the case of the Wadhurst Clay, which is reckoned to be 230 feet or more at Balcombe and Hellingley; but there is considerable difficulty in classifying the subdivisions of the Hastings Series. The Chalk, which is 790 feet thick at Chichester, has been proved to a depth of a little over 1,000 feet at Goodwood, and its full thickness there is reckoned to be about 1,200 feet. A map of the underground water-contours in the Chalk between the River Cuckmere and Eastbourne, is reproduced from a paper by Mr. H. M. Whitley; and although it represents observations taken between 1885 and 1889 it is interesting in showing the curves and fluctuations in the water-table.

Along the coastal Chalk tracts the level of the underground water rises and falls with the tide; and in some cases, as at Portslade, brackish water has been tapped by boring.

Dr. Mill remarks that "The distribution of average rainfall over the county corresponds very closely with the configuration of the ground, which in turn is dictated by the geological structure". The Alluvial tracts near Rye annually receive 25 inches of rainfall, the South Downs more than 30 inches, and near Upper Waltham probably more than 40 inches. Ashdown Forest, again, has a rainfall of 35 inches or more. It is noted that October is the wettest month, November, December, and January or September coming next. Thus, as remarked by Dr. Mill, so much rain falling during winter months, the county is favourably situated for accumulating a large quantity of underground water.

Apart from the many records of well-sinkings and borings, Mr. Whitaker contributes notes on springs, bournes, and swallow-holes; and also discusses the important question of contamination of waters, a subject exemplified by reports of cases dealt with by the Local Government Board.

2. Water Supply of Northampton.—Mr. Beeby Thompson, who as one of the authors of the Geological Survey Memoir on the Water Supply of Bedfordshire and Northamptonshire (1909) contributed a particular account of the old wells and other sources of supply for Northampton, has published an interesting, instructive, and more elaborate history of the town springs, wells, and water schemes (Journ. Northants Nat. Hist. Soc., vol. xv, 1909–10). The work is well illustrated with map, plans, and pictorial views of wells, pumps, conduits, and other structures connected with waterworks. It is noted that the "Scarlet Well" probably derives its name from the reputation of its water for giving to cloth a brilliant scarlet with the appropriate dyes in use in the thirteenth century or before. [We learn that the work can be purchased at Northampton from Mark & Co., price 1*s.* 6*d.*]

3. The Influence of Underground Waters on Health is a subject that was brought before the Royal Sanitary Institute (Journal, vol. xxxi, p. 457, 1910) by Mr. Baldwin Latham. Thus "Typhoid fever has been shown to break out not unfrequently after heavy rain", when the ground-water has been low. The rain then washes out the impurities from the porous strata as it descends to feed the ground-water from which domestic supplies are drawn. "When there is a large quantity of water in the ground we have healthy years, except when such high water follows a period of very low water."

4. Water Supply of the United States.—We have received a number of Water Supply Papers published by the United States Geological Survey. No. 255, "Underground Waters for Farm Use," by Mr. M. L. Fuller, is a general treatise on water supply and sanitary matters, including methods of sinking and boring, cost, etc. It is well illustrated. No. 254, "The Underground Waters of North-Central Indiana," is by Mr. S. R. Capps, with a chapter on the chemical characters of the waters by Mr. R. B. Dole. A full account is given of the geography, the geological formations and structure of the region, of the ground waters, artesian areas, and the supplies of water to various localities and for various purposes. No. 240, "Geology and Water Resources of the San Luis Valley, Colorado," by Mr. C. E. Siebenthal, deals with the geography and geology, the climate, agriculture, the alkali soils and the methods of irrigation, the springs, underground waters, flowing and non-flowing wells. Most of these subjects are also dealt with in No. 221, "Geology and Water Resources of the Great Falls Region, Montana," by Mr. C. A. Fisher. Other papers treat of the surface-water supply and the water powers of various regions in the United States.

5. Desert Water Supplies.—In the *Cairo Scientific Journal* (vol. iv, July, 1910) Mr. G. W. Grabham has questioned some of the explanations given by Mr. H. J. L. Beadnell with respect to the flowing wells in the Nubian Sandstone of Kharga Oasis (see Geol. Mag., 1908 and 1909), and suggests "that the constituents of sandstone, though incompressible, are slightly elastic, and when a bore is opened the ground in its neighbourhood may actually subside owing to the reduction of hydrostatic pressure beneath. This subsidence would react on the yield of the well in two ways, namely, expression of the accumulation of water and reduction in size of the sandstone pores, which, though very slight, would tend to reduce the rate of flow. When a bore is closed, the static pressure in its neighbourhood increases and again tends to elevate the ground". Mr. Beadnell replies in the same Journal (vol. v, January, 1911), and observes that "Even admitting, for the sake of argument, that the water held in the pores of a porous bed could be squeezed out by the pressure of the overlying rocks, we are faced by the difficulty of explaining how the water ever obtained access to the beds in the face of such pressure, which surely would have obliterated all such pores; or, again, how the water having been once expelled, could ever again be replaced". He mentions that the porosity of the Nubian Sandstone "varies both horizontally and vertically to a considerable degree", and that well-known facts connected with the fluctuation and depletion of artesian waters do not support Mr. Grabham's contention.

III.—The Natural History of Coal. By E. A. Newell Arber. pp. x, 163, with 21 text-illustrations. Cambridge: at the University Press, 1911. Price 1*s*. net.

THIS little handbook gives in clear and concise language a statement of the leading facts and theories concerning the various forms of coal and their origin, and commendable judgment is shown by the author in dealing with controversial matters. Space is found for a brief account of the history of coal, and, as the author remarks, it is not a mineral but a rock. Using the term in a popular sense he includes "Anthracite, the Humic or so-called Bituminous coals, the Sapropelic coals, which include the Cannels and Bogheads, the Brown coals, Lignites, and Peat". Their chemical properties, physical characters, and stratigraphical positions are duly pointed out, and the author then deals with the origin of peat, lignite, and the several varieties of coal, especially those of Carboniferous age. That there was an excessive amount of carbon dioxide in the atmosphere of the Carboniferous period is regarded as extremely doubtful. The "Peat-to-Anthracite theory" is rejected. Carboniferous coals were formed quickly, and although in the initial stage they may have resembled peaty deposits they did not necessarily pass through the stages of lignite, etc. Both peat and coal have been formed under a variety of circumstances, and the theories of 'growth-in-situ' and 'drift', as applied to coal, may be equally true. It is shown how coal may be formed under very different circumstances and from very diverse materials. Biochemical changes in plant debris were brought about by bacteria, and the author is led "to attribute a considerable share in the coal building of the Humic, Sapropelic, and Anthracitic types to regional, if not thermal, metamorphism".

As a companion volume of small dimensions, we may commend No. 21 of Gowan's Nature Books, 1909, price 6*d.* net, entitled *Fossil Plants*, and comprising sixty excellent photographs illustrating the flora of the Coal-measures, with explanatory notes, by Mr. Arber.

IV.—Geology for Engineers. By Lieut.-Colonel R. F. Sorsbie, R.E. pp. xxvii, 423, with 94 text-illustrations. London: Charles Griffin & Co., 1911. Price 10*s.* 6*d.* net.

THIS is a conscientious attempt to place before engineers all the geological information that may concern their professional undertakings. About half of the volume is taken up with the matter of an ordinary textbook of Geology: with Dynamic and Structural Geology, with Minerals, Mineral Chemistry, Crystallography, Rock-forming Minerals, and Rocks, and with Stratigraphy and Palæontology. There are illustrations of some of the commoner invertebrate fossils, brief descriptions of both invertebrata and vertebrata, and of the ranges in time of some prominent forms. A general account is given of the geological systems in Britain, and references are made to the occurrence of equivalent formations in various parts of the world. Here the information, though evidently sought out with care, is in some respects seriously behind the times. The tables of strata in North America, Australia, New Zealand, and South Africa are taken from Prestwich's Geology, vol. ii, 1888. Thus it comes to pass that the Acadian and Georgian (Middle and Lower Cambrian) are misplaced and grouped with Primordial under "Lower Silurian", while the Oriskany and Helderberg Beds, now grouped with the Devonian, are placed in Upper Silurian. *Eozoon canadense*, moreover, is recorded as a "problematic fossil". For these and many other statements the author refers to his authorities, unaware apparently of the additional knowledge acquired, and the consequent changes in nomenclature that have been made during the past twenty years.

There is a good general account of "Outdoor Work", but much of the "Indoor Work", such as the chemical analysis of rocks, other than blowpipe operations, must be left for the chemist. With regard to soils the author mentions that they "are best collected in artificial cuts or on the banks of streams, some 2 feet or so below the ordinary cultivated and altered surface"; but this will hardly apply, if the agricultural character of the soil is the object.

The subjects already mentioned occupy 236 pages; the remaining two-fifths of the volume (160 pages) are given to Practical Geology, to Water-supply, Building materials, Road-making, Earthworks of various kinds, including land reclamation and protection of sea-coasts, and to the uses of minerals for various purposes, including pigments. On these portions of his work the author writes with greater personal knowledge. While, however, he gives clear explanations of most of the phenomena, there are one or two illustrations, e.g. Figs. 84 and 87 in the section on water-supply, that are hardly intelligible or satisfactory. In the references to some of the building-stones the information quoted is not up to date: thus the Ketton and Ancaster stones, though formerly grouped with the Great Oolite, are now recognized as Inferior Oolite (Lincolnshire Limestone). The Aislaby Sandstone of East Yorkshire belongs, not to the Lias, but to the Lower Oolites (Lower Estuarine Series). A little more might have been said of the Scottish granites, those of Aberdeen and Peterhead not being described, although an analysis of the latter is given.

On the whole the work is rather overburdened with information that is of little practical value, but making allowance for the dates of publication of some of the works consulted the information has been gathered with evident pains and accuracy.

V.—Cambridge County Geographies.

THE Syndics of the Cambridge University Press are publishing, under the general editorship of Dr. F. H. H. Guillemard, a series of County Geographies suitable for general use as handbooks to the various counties, though primarily intended for use in schools. We have before us the volume on Cambridgeshire, by Professor T. McKenny Hughes and Mrs. Hughes (1909); Kent, by Mr. G. F. Bosworth (1909); Ayrshire, by Mr. John Foster (1910); and Fifeshire, by Mr. E. S. Valentine (1910).

The subjects are arranged in sequence, generally as follows, though naturally some of the topics are confined to particular counties: County and Shire, Physical Features, Rivers, Geology and Soil, Natural History, Coast (gains and losses), Climate and Rainfall, People and Dialect, Agriculture and Forestry, Industries and Manufactures, Minerals and Mines, Fishing, Shipping, History, Antiquities, Architecture, Roads, Railways, and Canals, Famous Inhabitants, Chief Towns and Villages.

The volumes are well printed and illustrated with views of scenery, buildings, celebrated individuals, etc., and they are accompanied by physical and geological maps, colour-printed. The price is 1*s*. 6*d*. In size the volume on Kent occupies 146 pages, that on Cambridgeshire 271 pages. In the latter, as might be expected, we have not only a concise account of the Geology and Soil, leading up to the Natural History and the introduction of the plants and animals, but a much fuller account than in other volumes of the Antiquities from Palæolithic times and of the Architecture. Although the Soil is mentioned, but little is said about it except in reference to Forestry, and the relations of the geology to Agriculture are not dealt with. Among special cultivations in Cambridgeshire that of woad is interesting, the plant *Isatis tinctoria* being still grown for dyeing purposes, and an illustration is given of the Woad Mill at Parson's Drove, Wisbech.

The article on the Geology and Soil of Kent is not very satisfactory: the Thanet Sands are not "quite destitute of fossils", nor are the septaria in the London Clay of Sheppey "nodules of carbonate of lime and iron pyrites". The Oldhaven Beds mentioned on the map are not referred to in the text, the Thanet Beds are not mentioned in the legend to the map, while the Bracklesham Beds there noted do not occur in Kent.

Good accounts of the geology and the soils and of the mines and minerals are given in the geographies of Fifeshire and Ayrshire.

There is no question that the series is an attractive one, and will be widely appreciated.

VI. The Kelvingrove Museum, Glasgow.—Introductions to the study of minerals and of rocks, including Guides to the respective collections in the Museum, have been prepared by Mr. Peter Macnair, F.R.S.E., the Curator of the Natural History Collections (8vo; Glasgow, 1910 and 1911; price 3*d*. each). The Guide to the Mineral Collections is illustrated by a plan of the Gallery where the specimens are displayed, by various forms of crystals, and by a plate depicting pseudomorphs of Gaylussite, dredged from the Clyde at Cardross. Curiously enough this mineral is not mentioned in the index, although briefly described on p. 63. The Guide to the Rock Collections is more fully illustrated with plan, pictorial views of rocks in the field, photographs of rock-specimens, micro-sections of rocks, and diagrams of the crystalline forms of rock-making minerals. These handy Guides should prove very helpful to students.

REPORTS AND PROCEEDINGS.

I.—The Royal Society.

February 2, 1911.—Sir Archibald Geikie, K.C.B., President, in the Chair.

The following communication was read:—

"On the Leaves of Calamites (*Calamocladus* Section)." H. Hamshaw Thomas, M.A., Curator of the Botanical Museum, Cambridge. Communicated by Professor A. C. Seward, F.R.S.

Most of the material investigated originally came from the Halifax

Hard Bed of the Lower Coal-measures. Most leaves were very small, being only 1–2 mm. long and ·8–1 mm. broad. They are falcate in shape, and were borne on slender twigs in alternating whorls of four. The structure of these slender twigs differs somewhat from that of the young Calamitean stems already described by Williamson and others, but it may be compared in some features with the structure of the young stems of some modern Equisetums.

The tissues of the small leaves show a concentric arrangement. In the centre there is a vascular bundle consisting of four or five small tracheides, surrounded by thin-walled elongated cells. The bundle is surrounded by a zone of cells with dense black contents, termed by Hick the melasmatic tissue, and is probably comparable with the bundle-sheath of the leaves of modern plants. The cells of the palisade-like assimilating tissue abut on to this; they have large spaces between them. The epidermis is thinner on the concave side of the leaf, and the stomata are situated on this face only. The latter are characterized by transversely striated guard-cells, similar to those seen in many species of modern Equisetums. These leafy twigs seem to be identical with the impression species *Calamocladus charæformis* (Sternb.); their structure seems to indicate that they grew in a pendulous manner. Specimens have been obtained showing variations in structure from the normal type.

Four other types of leaf have been discovered differing in size and in arrangement of tissues. In all of these there is a very conspicuous strand of sclerenchymatous fibres running up the adaxial side of the leaf, and forming a large part of its apex. These fibres become more conspicuous in the longer leaves. In some types the thin-walled (phlœm) tissue of the bundle is much reduced, or even absent. The melasmatic tissue also varies considerably in amount. Some of these longer leaves were probably identical with *C. grandis* (Sternb.); others with *C. equisetiformis* (Schloth.). They are characterized by a more compact structure, with smaller and fewer intercellular spaces.

The structure of the smaller leaves probably indicates that they grew in a moist situation, or where the atmosphere was humid. The larger leaves are more xeromorphic in character. The results obtained from this work indicate that the Calamites were truly microphyllous.

II.—Geological Society of London.

1. *March* 8, 1911.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The President announced that the Council had awarded the proceeds of the Daniel Pidgeon Fund for 1911 to Tressilian Charles Nicholas, B.A., Trinity College, Cambridge, who proposes to investigate the relations of the older rocks in the Lleyn Peninsula (Carnarvonshire).

The following communications were read:—

1. "Contributions to the Geology of Cyrenaica." By Professor J. W. Gregory and others.

(1) The Geology of Cyrenaica. By John Walter Gregory, D.Sc., F.R.S., F.G.S., Professor of Geology in the University of Glasgow.

According to the scanty evidence available in 1908 regarding Cyrenaica, which Hildebrand described in 1904 as "heute noch so gut wie unbekannt", the country might be interpreted as a fragment of a mountain-loop, an off-branch from the Atlas, or as a plateau of Miocene rocks.

In a journey across the country the author found that it was a plateau of Lower Kainozoic Limestones, which are classified as follows:—

OLIGOCENE (Aquitanian)	Cyrene Limestones.
EOCENE	Slonta Limestones = Priabonian.
	Derna Limestones = Moqattam Series of Egypt.
	Apollonia Limestones = Libyan Series of Egypt.

Some Miocene limestones occur in places on the plateau, and lying against its western foot.

These rocks are all limestones, containing very little clastic material. They must have been deposited in a clear sea, at depths ranging down to nearly 1,000 fathoms.

Intervals of shallow sea are indicated by some limestone conglomerates and a band of coral-reef limestone. The country was uplifted in later Miocene times, and was then part of a wide land which included Crete and occupied the site of the Ægean Sea. This land was broken up by great subsidences, which left Cyrenaica as a horst bounded by fault-scarps on the north and west. Eastwards the country sinks by a slight dip and a succession of faults, until the Miocene limestones, which occur on the plateau in Cyrenaica, are at sea-level on the coasts of Western Egypt. Cyrenaica may thus be regarded as part of the western limb of the geosyncline of Western Egypt.

The formation of the river-valleys probably began during a period of wetter climate than the present, but there is no evidence of any appreciable change in the climate or water supply since the date of the Greek and Roman colonization.

(2) Notes on the Kainozoic Mollusca. By Richard Bullen Newton, F.G.S.

The author determines a number of mollusca which are recognized as belonging to various members of the Kainozoic System, namely, post-Pliocene, Helvetian–Tortonian or Vindobonian, Aquitanian, Priabonian, and Lutetian. The most abundant of the post-Pliocene series is *Cerastoderma edule*, a species largely distributed over Northern Africa and the Mediterranean countries generally. Among the Helvetian–Tortonian forms are *Alectryonia* cf. *virleti* and *Strombus* cf. *coronatus*—well known in North African rocks of this age, as well as in those of other Mediterranean regions.

The Aquitanian shells present a relationship to the 'Schioschichten' fauna of Northern Italy, and consist mainly of Pectinoid species, such as *Pecten vezzanensis*, *Æquipecten* cf. *pasinii*, and *Spondylus cisalpinus*, etc., associated with *Æquipecten zitteli*, *Æq. camaretensis*, and *Æq. scabrellus*, which are indicative of the later age—Burdigalian or Helvetian. This admixture of species, according to Dr. Oppenheim's memoir on the 'Schioschichten', is also known in the fauna of those rocks. Foraminiferal organisms (*Operculina*, etc.) occur in these beds, but no nummulites. *Lepidocyclina elephantina*, a good Aquitanian species, is found with *Oopecten rotundatus* from Birlibah.

The most characteristic of the Priabonian mollusca is *Pecten arcuatus*, a species occurring in Northern Italy, the Balearic Islands, Algeria, Tunis, the Balkan Peninsula, Armenia, etc. A new species of *Æquipecten* is described. Nummulites abound in these rocks.

An indeterminable ostreiform shell has been collected in the neighbourhood of Ain Sciahat, associated with the large *Nummulites gizehensis*—thus demonstrating that Lutetian rocks are present in Cyrenaica. So far as the mollusca are concerned, nothing older than Lutetian has been observed in this collection.

(3) Foraminifera, Ostracoda, and Parasitic Fungi from the Kainozoic Limestones of Cyrenaica. By Frederick Chapman, A.L.S., F.R.M.S.

This paper describes the Foraminifera, Ostracoda, and a parasitic fungus found in the limestones of Cyrenaica. The Foraminifera are mainly from the Middle Eocene; others belong to the Upper Eocene, and to the Aquitanian or Stampian. The most abundant Foraminifer is *Nummulites gizehensis*, which is represented in the Derna Limestones by its typical form, and is there associated with the typical form and a new variety of *N. curvispira*. At a higher horizon below Ain Sciahat and in the Slonta Downs is a nummulitic limestone containing *N. gizehensis*, var. *lyelli*.

Some limestones at Wadi Umzigga contain *Lepidocyclina elephantina*, and are referred to the Aquitanian or Stampian.

Further details are given of the structure of *Orthophragmina pratta*. A new species of *Loxoconcha* is described. The boring fungus *Palæachyla perforans* occurs perforating *Lepidocyclina*.

(4) The Fossil Echinoidea of Cyrenaica. By John Walter Gregory, D.Sc., F.R.S., F.G.S.

The Echinoidea collected in the journey across Cyrenaica are referred to ten species, of which two are new and one is a new variety. The echinoids come from four horizons: the oldest fauna belongs to the Middle Eocene; the Upper Eocene or Priabonian fauna is represented by an unusually early species of *Amphiope*, and by an *Echinolampas* which is widely distributed through the country and is referred to the Priabonian *E. chericherensis*, Gauth. Some echinoids from the Cyrene Limestones are of Aquitanian affinities, and others seen in the limestone east of Benghazi are Miocene. The affinities of *Hypsoclypeus hemisphericus* (Greg.) are considered. The echinoid faunas show that the Eocene rocks containing them were, as a whole, deposited in a sea of moderate depth. The Miocene strata were formed in comparatively shallow water.

(5) The Foraminiferal Limestones of Cyrenaica. By David Paterson MacDonald, M.A., B.Sc.

The microscopic examination of the limestones of Cyrenaica shows that they are all mainly composed of organic material, and are remarkably free from detrital material. The rocks were laid down under conditions of quiet sedimentation. Some of them have been partly dolomitized. The chalky limestones near the base of the series have been deposited at the greatest depth. The commonest organisms present are Foraminifera, Echinoderms including holothurian plates, Mollusca, and calcareous Algæ, which in some specimens form more than half of the whole rock. Some of the limestones are oolitic.

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2. "On the Teeth of the genus *Ptychodus*, and their Distribution in the English Chalk." By George Edward Dibley, F.G.S.

This paper is an attempt to define the species of the fossil fish genus *Ptychodus*, and gives the result of the investigations pursued by the writer during the past twenty years among the extensive Chalk quarries in the Thames and Medway Valleys, West Kent, and the adjoining parts of Surrey, with reference to the zonal distribution of the genus.

The Medway Valley affords special facilities for such investigations, as there are numerous quarries worked there, from the *Micraster cor-anguinum* zone down to the Chalk Marl. In addition to material from the above-mentioned localities, material collected from the contents of the chief provincial museums, and also the specimens in the National Collections at the British Museum (Natural History) and the Museum of Practical Geology, Jermyn Street, have been studied in detail by the author, who has obtained no less than fifty associated sets of teeth from various localities.

Hitherto, our information as regards *Ptychodus* has been derived from associated sets of *Pt. decurrens* in place and isolated teeth of this and other species. The variation in teeth of one individual is often so marked, that when found separately they have given rise to the formation of new species. From evidence now brought together by the author for the first time, it can be proved that these teeth belong to already known species, and merely represent a phase in variation in the development of certain teeth of one species.

Special attention has been given to the extreme variation in *Pt. decurrens*, as well as in the equally variable species *Pt. polygyrus*, and one new species has been added.

A special feature is, that throughout the species a series of teeth extending from the centre to the exterior of the palate is figured, which also for the first time enables the student to form some idea of the variation exhibited by the separate rows, even in the teeth of the same individual, and indicates the care necessary in identifying species when dealing with solitary teeth.

III.—Mineralogical Society.

March 21, 1911.—Prof. W. J. Lewis, F.R.S., President, in the Chair.

Professor W. J. Lewis: On Mr. Solly's observation of Wiltshireite in 1903. Wiltshireite is identical with the mineral which Mr. Solly exhibited and described before the Society November 17, 1903, and subsequently named rathite *a*, but of which no complete description has yet been published.—R. H. Solly: Two new minerals from the Binnenthal, Switzerland. Both are probably sulpharsenites of lead, being lead-grey in colour and giving a chocolate-coloured streak; one, which is rhombohedral-diplohedral, and has an angle 111 : 100 = 38° 18′, is probably isomorphous with trechmanite, while the other may be orthorhombic, the angle 100 : 110 being 58° 18′, but no measurable end faces were observed.—J. B. Scrivenor: Notes on Cassiterite in the Malay Peninsula. Cassiterite from a mine at Gopeng contains ilmenite and magnetite, and is attracted by the magnet; it also occurs mixed with tourmaline pseudomorphic after an hexagonal mineral, probably quartz. Arthur Russell: Notes on the occurrence of Dundasite in Derbyshire and Co. Galway, and of Bertrandite in Cornwall. Dundasite was discovered at Mill Close Mine, Wensley, Derbyshire, as snow-white spheres associated with greenockite, fluor, cerussite, calamine, etc., and at Clements lead mine, Carrowgarriff, near Maam, co. Galway, associated with allophane and cerussite, and bertrandite was found in platy crystals on old specimens of blende from Wheal Vor, Breage, Cornwall, and as trillings, measuring up to 4 mm. in length, on a specimen from Wheal Metal, Breage, Cornwall, which had been presented as albite to the British Museum in 1870; in the latter case the crystals were similar to those from Pisek, Bohemia, described by C. Vrba.—Dr. J. Drugman: On Quartz-twinning. The possible varieties of twinning of quartz were discussed, with special reference to the rhombohedron type, a specimen of which was exhibited.—T. V. Barker: Crystallographic Notes. Two new forms found on crystals of inosite confirm the hypohexagonal type of symmetry suggested by Fedorow. The rhombohedral modification of potassium nitrate, unlike sodium nitrate, does not arrange itself regularly when deposited on a cleavage piece of calcite; the crystals are very unstable, and rapidly pass into the ordinary orthorhombic form. A parallel growth of calcium chromate on the isomorphous mineral gypsum was obtained. New forms have been observed on urea nitrate which enabled the axial ratio *b* : *c* for the first time to be calculated; the crystals have large birefringence, and, when grown in a drop, are nearly always twinned.

CORRESPONDENCE.

THE LAND-ICE HYPOTHESIS.

Sir,—In his letter in the last number of the Magazine (for April, p. 189), Mr. Deeley suggests that ice resting on frozen ground "would freeze to it and drag it along". I remember to have seen evidence of the rock on which *Boulder-clay* rests having been thus dragged along. The hill between Hastingfield and Barrington, near Cambridge, consists of Lower Chalk, or clunch, capped by Boulder-clay. Near the south crest of the hill, on the west side of the road, there is a large clunch pit, now little used, and when I last saw it the section was concealed. But a good many years ago the junction of the Boulder-clay and the clunch was well exposed. The clay contained many glaciated pebbles of clunch, but the point of interest was that the clunch beneath the clay showed signs to the depth of several feet of having been dragged along, for it contained horizontal shearing planes, and was full of slickensides. The mechanics of this kind of action is not very obvious. It would not seem at first sight that this case was quite analogous to that supposed by Mr. Deeley, because it was not ice, but clay, which appeared in contact with the disturbed clunch.

Now though ice may be regarded as a highly viscous fluid, flowing, though slowly, like water, yet this condition cannot be predicated of Boulder-clay, much less so if the clay were frozen. But if it were not frozen, and was dragged along by a deep layer of ice that covered it, it can hardly be supposed that the ice communicated its own motion to the whole thickness of the plastic Boulder-clay, and through it to a considerable depth of solid clunch besides. Or was the clunch disturbed by the ice itself, in accordance with Mr. Deeley's suggestion, before any ground moraine had reached the locality?

The subject is worth investigation, and I would advise Cambridge geologists to keep a look out for the section being again exposed, or possibly to get it reopened for the purpose of examining it. A man with a pick and shovel could do it in an hour or so.

O. Fisher.

Graveley, Huntingdon.
April 19, 1911.

'FACETTED PEBBLES' AND 'DREIKANTER'.

Sir,—The reviewer of Messrs. Lake & Rastall's Text-Book of Geology (Geol. Mag., February, 1911, p. 85) states that the use of 'dreikanter' and 'zeugen' is pedantic and ill calculated to advance knowledge, and evidently considers that the expressions 'facetted pebbles' and 'tabular outliers' are equivalent, or "sufficient" as he calls it. Apart from the reviewer being wrong in both cases, the terms are recognized and used by geologists of many nationalities, and it is surely desirable in a textbook to employ standard words which the advancing student is likely to meet with elsewhere. If the suggestion of the reviewer were adopted and carried to its logical conclusion, the already considerable obstacle of language would be increased by each nation having its own set of scientific expressions.

A pebble may be facetted by glacial action, but there are characters which would often enable us to distinguish it from a dreikanter. The selective action of the wind-blast on softer parts of the rock may produce furrows, but these are not to be confused with glacial striæ.

A zeuge may take the form of a tabular outlier when it is formed of horizontal strata, and then only if there is a suitable arrangement of hard and soft beds. In country of massive, folded, or crystalline rocks the zeugen would not be tabular and 'outlier' a misnomer. I have just had the privilege of traversing some 800 miles of desert with no less an authority than Professor Walther, and in the course of our journeys we saw many hills of this type. They are formed in the denudation of plateaux and stand forward on the plain in evidence of the former extent of the elevated land. The term 'zeuge' expresses this and may be rendered as 'sentinel rock' or 'témoin'.

I have not yet had the pleasure of seeing the textbook in question and consequently am unacquainted with the definitions given by the authors. If their terms are really ill calculated to advance knowledge, those of the reviewer would probably confound it.

G. W. Grabham

(*Geologist to the Soudan Government*).

Khartoum.

March 17, 1911.

MISCELLANEOUS.

Australian Association for the Advancement of Science. Award of the Mueller Medal. Sydney University, January 9, 1911.—At the opening meeting of the Association, under the presidency of Professor D. Orme Masson, M.A., D.Sc., F.R.S., of Melbourne, the Council awarded the Mueller Memorial Medal to Mr. Robert Etheridge, Curator of the Sydney Museum, for his past services in the cause of science, particularly in connexion with palæontology, ethnology, etc. Mr. J. H. Maiden said Mr. Etheridge's work as a bibliographer was unsurpassed. Prior to his residence in Sydney, he had served as an officer on the Geological Survey of Victoria and of Scotland, also in the British Museum (Geological Department). Dr. Hall, of Victoria, and other eminent geologists testified to the invaluable services rendered to all the Colonies by Mr. Robert Etheridge's work as a palæontologist. His friends in England and Scotland will rejoice to hear the honour conferred upon him by the Australian Association.—*Sydney Evening News*, January 9, 1911.

Remarkable Tide at Aldeburgh.—Great damage was caused at Thorpness, Aldeburgh, on April 3, by the high tide, the beach being diminished to an extraordinary extent. The bungalows, formerly a hundred yards away, are now within a few feet of high-water mark. The seas have washed out of the sands hundreds of coins, gold, silver, and bronze, dating from early Saxon times, antique bronze rings and ornaments, and an old bronze bag clasp with a silver inscription, said to be of King John's period.—We quote the above record from the *Morning Post*, April 4, and may at the same time recall attention to the paper on "Recent Coast Erosion at Southwold and Covehithe" by Mr. John Spiller (Geol. Mag., January, 1896, p. 23).

International Congresses.—The Fourth International Philosophical Congress assembled at Bologna in April, when, among other subjects discussed, Professor Emile Boutroux dealt with the relationship of philosophy and science. As remarked by Sir A. Geikie in his address to the Royal Society in 1909, this aspect of scientific thought "is too apt to be overlooked amidst the engrossing pressure of modern research".

HENRY KEEPING TESTIMONIAL.

We have been requested to announce that Mr. Henry Keeping, who has been for fifty years Curator of the Geological Museum, Cambridge, is now retiring from active work, and it is felt by many with whom or for whom he has worked that this would be a fitting opportunity for expressing their appreciation of his long service in the cause of Geology. It is therefore proposed to offer him a purse on his retirement at the end of the Easter term.

Subscriptions will be received by Mr. F. R. Cowper Reed, M.A., F.G.S., Sedgwick Museum, Cambridge, and cheques should be made payable to the "Henry Keeping Testimonial Fund", and crossed Capital and Counties Bank, Cambridge Branch.

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PROFESSOR J. W. GREGORY, D.Sc., F.R.S., F.G.S.
DR. GEORGE J. HINDE, F.R.S., F.G.S.
SIR THOMAS H. HOLLAND, K.C.I.E., A.R.C.S., D.Sc., F.R.S., F.G.S.
PROFESSOR W. W. WATTS, Sc.D., M.Sc., F.R.S., PRES. GEOL. SOC.
DR. ARTHUR SMITH WOODWARD, F.R.S., F.L.S., SEC. GEOL. SOC., AND
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JUNE, 1911.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VIII.

No. VI.—JUNE, 1911.

ORIGINAL ARTICLES.

I.—On some British Pillow-lavas and the Rocks associated with them.

By Henry Dewey and John Smith Flett.

(By permission of the Director of H.M. Geological Survey.)

(*Concluded from the May Number, p. 209.*)

If we take a rapid glance over the volcanic history of the British Isles we find that eruptions having the spilitic facies have occurred repeatedly, over a wide area and on a large scale.

Pre-Cambrian. Among the Dalradian Schists of the West of Scotland pillow-lavas were first recognized by Peach (30). They are well shown on the shore at Tayvallich on the Sound of Jura, and extend thence through Argyllshire past Loch Awe. Representatives of this series are met with at Ardwell in Banffshire. The accompanying sediments are the quartzites, black shales, and limestones of the Central Highlands. Albite-diabases represent the intrusive phase, and there are also keratophyres and soda-granites. The age of this series is uncertain, but perhaps it is pre-Cambrian.

In Anglesey and the Lleyn District of Carnarvonshire pillow-lavas with variolitic structure have been described by Raisin (31) and Greenly (32). With them there are diabases and cherts, but no acid rocks are known. These also are perhaps pre-Cambrian.

Cambrian (?). Radiolarian cherts and pillow-lavas occur in a narrow strip along the southern border of the Scottish Highlands extending from Stonehaven into Arran. Diabases accompany them, but no acid rocks, though serpentine and gabbro are found in lenticles, the relations of which to the lavas and cherts are unknown. The sediments are black shales, grits, and limestones, and Dr. Peach thinks it likely that they will ultimately prove to be Upper Cambrian (33).

Ordovician. To this series belong the Arenig volcanics of the South of Scotland and the Arenig or Llandilo pillow-lavas of South Cornwall. In both places there are diabases, keratophyres, and soda-felsites or soda-granites.

About the same time there were eruptions in South Wales emitting keratophyres, soda-felsite, variolite, and diabase, and Thomas (34) has found a remarkable suite of rocks on Skomer Island that presents many resemblances to the Arenig igneous rocks of South Scotland, though only one or two flows of pillow-lava have been detected in it. They include keratophyre, soda-trachyte and soda-felsite, diabase (not albitized), and basic rocks rich in albite, called skomerite and marloesite. In Ireland Reynolds and Gardiner have found typical pillow-lavas, cherts, and diabases of Arenig age.

In Upper Silurian times no spilitic eruptions have yet been recorded in Britain.

Devonian. The great development of spilite and schalstein in Cornwall and Devon perhaps began in Middle Devonian times, and attained its maximum in Upper Devonian or Lower Carboniferous times. They are accompanied by albite-diabase, minverite, quartz-diabase, picrite, and quartz-keratophyre.

The subjoined table shows the facies developed from the magma in each epoch at different localities :—

	Soda-granite.	Soda-felsite and Quartz-keratophyre.	Keratophyre.	Spilite.	Diabase.	Quartz-diabase.	Minverite.	Picrite.
Argyllshire . . .	1	—	1	1	1	1	?	—
Anglesey and Lleyn	—	—	—	1	1	—	—	—
Stonehaven . .	—	—	—	1	1	—	—	—
Southern Scotland	—	1	1	1	1	—	—	—
South Cornwall .	1	—	1	1	1	—	—	—
South Wales . .	—	1	1	1	1	—	—	—
Devon and Cornwall	—	1	1	1	1	1	1	1

Harker (35), Prior (36), and Becke (37) have of recent years established the existence of two great suites of eruptive rocks, the Atlantic and the Pacific, and their conclusions have been accepted by Suess (38). In the British Isles we have many examples of these in past time. The Tertiary eruptions of Scotland are of Atlantic facies; the Carboniferous of the Scottish Lowlands are Atlantic also, but the Old Red are Pacific, while the Ordovician are of the spilitic type.

In Devon and Cornwall the Ordovician eruptions were spilitic, the Devono-Carboniferous were spilitic, but the Permian were Atlantic, and characterized by trachytes rich in potash. From this we see that the same region may in successive geological epochs be the focus of eruptions of entirely distinct suites of volcanic rocks.

The Pacific volcanic rocks are generated by epochs of active folding, the Atlantic by vertical movements attended by faulting. The spilitic group is characteristic of off-shore subsidences. They are the characteristic volcanic rocks of districts that have been undergoing long-continued subsidence (39). Hence they are not found on the land at the present day, and, in the past, their commonest associates are fine black shales, limestones, and radiolarian cherts.

It is interesting to recall that in Lower Ordovician times, while the spilites and keratophyres of Southern Scotland and the South of

Cornwall were being poured out, eruptive centres in Cumberland were emitting hypersthene andesites and other rocks of Pacific type: on the other hand, in the Lower Carboniferous period, spilites and quartz-keratophyres were the characteristic lavas of Devonshire and Cornwall, while trachytes, phonolites, olivine-basalts, teschenites, and nepheline-basalts of Atlantic facies were the dominant igneous rocks of East Lothian in Scotland.

In 1899 Teall (25) remarked that "it is interesting to note that at Ballantrae in Cornwall and in Mont Genèvre diabasic lavas with pillow-structure occur in the immediate neighbourhood of gabbro and serpentine, and that in all three localities some difficulty is experienced in determining the precise relations of these rocks". The constant association of diabase (spilite), serpentine, and gabbro in the northern Alps with radiolarian cherts has led Steinmann (37) to regard these 'ophiolitic eruptives' as the typical volcanic rocks of abysmal depressions. Suess has accepted and extended this hypothesis, considering the 'green rocks' to be injections into folded ranges associated with dislocations, but not invariably with deep-sea conditions (38). The 'ophiolitic eruptives' of Steinmann are not coextensive with the spilitic suite of igneous rocks as here defined, and still less so are the 'green rocks' of Suess. In several parts of Britain the association of gabbro and serpentine with spilitic lavas is difficult to explain as a mere accident, but we have not been able to establish definitely, in those parts of Cornwall or of Scotland with which we are personally familiar, that the one series is the plutonic representative of the other. For the present we prefer to regard this as an open question, hoping to return to its consideration at some future time.

The Adinoles.

That type of alteration by which shales and slates are converted into adinoles has been produced by basic intrusive rocks of more than one class. In the Lothians, for example, it occurs at the margins of some teschenite sills, and quartz-diabases sometimes also induce it. But there can be no doubt that the albite-diabases that belong to the spilite suite of igneous rocks are more efficient in changing shales to adinoles than all the other kinds of diabase. In Cornwall and Devon adinoles occur with great frequency both in the Devonian and Culm, and the adinole of Dinas Head is especially well known through the descriptions of Fox and Teall and the analyses of Hort Player (40). We may further remind our readers that an extensive literature has been written about the similar rocks of the Rhine district, which also occur in contact with the late Devonian and early Carboniferous intrusive sills that belong to the spilitic volcanic series.

The adinoles in their highest development are nearly pure albite rocks. No shales have a similar composition, for none are so rich in alkalies, yet the transformation of a shale into an adinole often takes place within a few inches. Hence there is no escape from the conclusion that there has been an infusion of new substances, principally soda, into the sediment, and this has been generally admitted by petrographers for many years. For a summary of the literature on this subject we may refer to Roth (41).

In its microscopic structures the adinole is no less evidently a recrystallized sediment. The lamination, cleavage, and bedding are soon lost, and a cryptocrystalline or finely crystalline rock is produced that has the closest resemblance to a chert. In North Cornwall and Devon cherts and adinoles constantly occur together in the same quarry. Very often they can hardly be distinguished except for the fact that the felspar of the adinole has a lower refractive index than balsam, while the quartz has the same or slightly higher; moreover, the adinoles are fusible while the cherts are not. By further recrystallization the adinoles become a mosaic of albite grains that have very closely the same mode of aggregation as the silicified shales found associated with some mineral veins (such, for example, as the flinty Ordovician shales of Parys Mountain in Anglesey). Now the cherts are admittedly rocks that have been recrystallized from colloid organic silica through the agency of aqueous solutions, and an allied mode of origin seems probable for the adinoles. In the latter we may often note the meshwork of veins filled with albite slightly more crystalline than the matrix, through which the solutions were introduced. The adinoles consist of quartz, albite, and chlorite (with rutile and iron oxides), and these are also the minerals that most characterize the post-volcanic or pneumatolytic stage of crystallization in the albite-diabases.

That adinoles should accompany albite-diabases is exactly what might be expected, for the pneumatolytic or post-volcanic vapours by which the intrusive rocks were albitized provide also the necessary constituents for the albitization of the sediments. In this respect the adinoles are not unlike the tourmalinized killas that occurs at the margins of the Cornish granites, where the same vapours as attacked the sediments also attacked the granite itself, converting it into schorl rock. The remarkable chemical changes that take place in the transformation of shale into adinole are the clearest evidence that could be adduced to show that vapours or solutions rich in soda were emitted by the igneous rocks during the later stages of their crystallization.

The Cherts.

That pillow-lavas are usually accompanied by radiolarian cherts is now a well-established fact. Attention has been directed to this paragenesis by Teall (42), and in all parts of Britain in several geological epochs it has since been proved to hold good.

As already stated, the spilitic rocks occur typically as submarine lavas in regions remote from shore-lines where the water is of considerable depth. These also are in a high degree the conditions that seem favourable for the deposition of siliceous organic deposits. The association then is a natural one, just as radiolarian cherts occur with fine graphitic shales and limestones.

But this is not the whole truth. How often do we find the cherts nestling in the hollows between the pillows even where limestones are few or absent, and where the sediments are of rather coarse grain and belong to shallow-water facies. In Cornwall pillow-lavas are found in the Middle and Upper Devonian; the attendant sediments are shales and grits, but Ussher (43) found that between the pillows of the lava on the shore at Saltash a few thin beds of chert occur, and in microscopic section they appear to be of radiolarian origin. No cherts are found in the Devonian rocks at lower levels, but as soon as the spilites are met with the cherts also make their appearance, and at first are only found on the upper surfaces of the flows. This fact awakens a strong suspicion that there must be some genetic connexion between these two kinds of rock. At higher horizons in Upper Devonian and Culm the pillow-lavas abound, and there are great masses of chert, but we cannot be sure that this is more than a coincidence, since in South Wales at the same time radiolarian cherts were being laid down in great sheets, and there are no pillow-lavas. Again, in the Lower Palæozoic rocks of Cornwall, as Fox (44) has shown, there are sometimes a few lenticles of chert among the black shales, but when the pillow-lavas flowed out on the sea-bottom in Arenig or Llandeilo time the cherts appeared at once in great quantity, and on Mullion Island they fill up the gaps between the sack-shaped masses of the igneous rock.

Recent researches on the plankton of the northern seas have proved that the modern organisms which form siliceous tests are dependent on the supply of silica in the water which they inhabit (45). At certain seasons a large increase in the amount of dissolved silica takes place, and this is followed almost immediately by rapid proliferation of the diatoms, etc., that inhabit the water. There seems no inherent reason why the 'law of the minimum', as it has been called, may not also have held good in Palæozoic times; if so, it explains the occurrence of organic cherts with pillow-lavas. The igneous rocks as they cooled down exhaled vapours or solutions of magmatic origin, rich in dissolved silicates of soda and other bases. These were the agencies which albitized and decomposed the lavas, and any excess must have escaped into the sea-water. In this way precisely those conditions were provided which are most favourable to the rapid multiplication of siliceous protozoa such as the radiolaria. As the spilitic rocks are generally found at some distance from the shore, in quiet waters where there was little sediment and current action was at a minimum, the radiolaria, though they may have been of slow growth, were not carried away. The dead shells fell to the bottom and rested on the surface of the lava, while there was comparatively little clastic or land-derived sediment to mingle with the siliceous organic deposit. Where there are no cherts with the spilites, as for example at Tayvallich, Argyllshire, we may infer either that the dissolved mineral substances were not in excess of those required to albitize the lava, or more probably, that the local action of currents bore away the minute siliceous shells and brought other sediment in their place.

Conclusions.

1. The pillow-lavas are members of a natural family of igneous rocks, the spilitic suite, that can be clearly distinguished from the Atlantic and Pacific suites.

2. This family comprises a great variety of types—picrites, diabase,

minverite, quartz-diabase, spilite, keratophyre, quartz-keratophyre, soda-felsite, and albite granite, ranging from ultra-basic to acid in composition.

3. Their essential characteristics are the abundance of soda-felspar, and the remarkable frequency with which they have been albitized.

4. The albitization is not characteristic of the whole suite, but is especially frequent in certain members of it, such as the spilites and diabases, while others like the quartz-diabases are less liable to this change. It is not due to weathering or shearing. Good evidence exists to prove that the albitization took place soon after the rocks had solidified, and consequently it may be grouped among the post-volcanic or juvenile changes of rock-masses.

5. The constant association of adinoles (albitized shales) with the albite-diabases, and of radiolarian cherts with pillow-lavas, finds a simple explanation on this hypothesis, and at the same time affords the strongest confirmation of it.

6. The composition of the pneumatolytic emanations cannot be exactly defined, but it is certain that they consisted of water with soda and silica in solution; probably also carbonic acid was abundant, and many other substances may have been present.

7. In the British Isles spilitic eruptions have appeared in great numbers in all the Palæozoic formations (with the exception of the Upper Silurian and the Permian), and in the Tayvallich Volcanic Series have an important development among the metamorphic schists of the Scottish Highlands.

8. Like the Atlantic and Pacific igneous suites they have an intimate connection with certain types of geographical conditions. They are essentially rocks of districts that have undergone a long-continued and gentle subsidence, with few or slight upward movements, and no important folding.

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II.—The Fundamental Problems of Petrogenesis, or the Origin of the Igneous Rocks.

By Dr. Franz Lœwinson-Lessing, Professor of Mineralogy and Geology, Polytechnic Institute, Sosnovka, St. Petersburg, Russia; For. Corr. Geol. Soc. Lond.

Introduction.

The question of the origin of igneous rocks, their diversity and genetic relationships, represents that fundamental problem of petrography which has been for many years the object of inquiry for petrologists as well as for geologists and chemists. Whilst the amount and scope of detailed observation were growing, the methods of experimental investigation improved, and as the eruptive rocks came to be studied from the point of view of physical chemistry, so the petrogenetical horizon became larger and wider. Thus, on the basis of numerous minute and detailed observations were built broad generalizations that gave rise to new problems.

If we try to determine by one word the successively predominant ideas in petrogenesis, we can say that, notwithstanding a certain diversity of opinions, from 1890 and for nearly fifteen years petrology was dominated by the idea of differentiation; from the middle of the last decennium the chief rôle belongs to the theory of eutectics; and during the last few years there has been slowly growing and advancing, as a necessary corollary and even as a dominant factor, the hypothesis of refusion and assimilation by fusion. A rational combination of the principles of assimilation, refusion, differentiation, and eutectics seems to be the best basis for a theory of the genesis and diversity of the igneous rocks, and probably the nearest approximation to the solution of the question may be my syntectic-liquational hypothesis [1] enlarged according to the progress of later years.

In the present paper [2] I propose to give my revised views on the genesis of the igneous rocks and the factors governing their diversity.

§ 1. *The Average Chemical Composition of the Earth's Crust and the Primordial Magma.*

Before entering into the problem of the genesis of the igneous rocks it is necessary to deal critically with a question of general interest, which has often been an object of inquiry for petrographers and chemists.

[1] F. Lœwinson-Lessing, "Études de pétrographie générale," p. 178: Trans. Soc. Nat. St. Pétersbourg, 1898. "Studien über die Eruptivgesteine," p. 187: Compt. rend. Congr. Géol. Inter., St. Pétersbourg.

[2] Originally written in Russian, August 27, 1910, and printed in the Annales de l'Institut Polytechnique de St. Pétersbourg, v, xiv, 1910, p. 111.

I mean the average chemical composition of the earth's solid crust as a whole, and especially that of the igneous rocks.

The problem of determining this average composition is very attractive. It is well known that the most important contributions to the solution of this problem have been given of late years by F. W. Clarke,[1] H. S. Washington, and Vogt. Without denying the value of their calculations and reasonings for elucidating the question of the relative abundance of the different elements in the solid crust, I must nevertheless state that the method used by these and other authors for calculating the average composition is in principle erroneous, and consequently the result is arbitrary. The arithmetical mean of hundreds or even thousands of analyses, when the relative quantities of the different types of rocks are not taken into consideration, has no serious value. Nevertheless the result is probably very near to the real average composition, as will be subsequently shown, because the figures given by Clarke[2] and several other authors represent approximately the mean of the composition of granite and gabbro (or basalt); and these two magmas are not only the most widely spread, but they seem to enter into the composition of the crust in nearly equal quantities. If we take, then, the mean only from the figures for granite and gabbro (basalt) we get a result which in essential features is nearly identical with the mean calculated from an arbitrary number of separate analyses of all known types of igneous rocks. But it is not this average magma, having nearly the composition of a syenite, which I consider the primordial terrestrial magma, and I do not think that all other rock-types such as granites, gabbros, etc., are derivates, produced by differentiation of one fundamental magma. On the contrary, as will be shown later, my hypothesis consists in admitting that there are two and only two fundamental magmas—the granitic and the gabbroidal (= basaltic), and that the eruptive rocks are derived from these two magmas by differentiation and assimilation.

TABLE I.

	I.			II.	III.	IV.		
	%			%	%	%		
SiO_2 . .	59·57			58·24	60·91	59·57		
Al_2O_3 . .	14·82	18·46		15·80	15·28	15·54	18·52	
Fe_2O_3 . .	3·64			3·33	2·63	2·98		
FeO . .	4·12			3·87	3·46	3·67		
MgO . .	3·40	13·05		3·84	4·13	3·98	12·70	
CaO . .	5·53		19·27	5·22	4·88	5·05		19·45
Na_2O . .	3·20	6·22		3·91	3·45	3·68	6·75	
K_2O . .	3·02			3·16	2·98	3·07		
TiO_2 . .	1·36			1·04	0·73	0·89		

[1] See, for instance, Clarke, "The Data of Geochemistry": Bull. U.S. Geol. Surv., No. 330, 1908.

[2] It must be noticed that in calculating the average composition of the whole crust Clarke (ibid.) takes for the sediments and the eruptives certain coefficients corresponding to their relative quantities in the solid crust. But why is the same method not applied to the calculation of the average for the eruptive rocks?

On Table I are given: (I) The average from basalt (after Daly [1]) and granite (after Holmquist [2]); (II) Washington's [3] and (III) Clarke's average for igneous rocks; (IV) the average between II and III. We can easily see that this last average agrees in its essential features with the composition of an earth magma, presumed to consist of equal parts of a granitic and a gabbroidal magma.

The same result is reached by taking the new data of Daly,[4] as can be seen from the figures on Table II. Washington's average and the mean from granite and gabbro are in the essential lines identical.

TABLE II.

	I.	II.	III.		IV.		V.	VI.	
	Granite after Daly.	Gabbro after Daly.	The mean of I and II.		The mean after Washington,[3] p. 114.		Basalt after Daly.	The mean of I and V.	
	%	%	%		%		%	%	
SiO_2	70·47	48·95	59·71		59·21		49·87	60·17	
TiO_2	0·39	0·98	0·68		1·06		1·38	0·89	
Al_2O_3	14·90	18·15	16·52	18·94	16·04	19·42	15·96	15·43	18·98
Fe_2O_3	1·63	3·21	2·42		3·38		5·47	3·55	
FeO	1·68	6·04	3·86	15·05	3·93	13·13	6·47	4·07	13·55
MnO	0·13	0·13	0·13		—		0·32	0·23	
MgO	0·98	7·62	4·40		3·90		6·27	3·62	
CaO	2·17	11·15	6·66		5·30		9·09	5·63	
Na_2O	3·31	2·59	2·95	5·45	3·97	7·18	3·16	3·24	6·06
K_2O	4·10	0·90	2·50		3·21		1·55	2·82	
P_2O_5	0·24	0·28	0·26				0·46	0·35	

Our first conclusion can be formulated as follows: The average composition of the crust, calculated by the method hitherto in use, corresponds to the composition the crust would have if it consisted of equal parts of granite and gabbro. What does this hypothetical fundamental magma represent? Examining the answers to this question given by different authors, we perceive that the current opinions are erroneous. Thus Daly, with whom I agree on many points, is wrong when he defines this magma as a dioritic one, because in calculating the average composition of diorite he has taken analyses, not of diorites only, but also of quartz-diorites (granodiorites) representing a different magmatic type from that of true diorites. In reality the average III on Table II corresponds almost exactly to the syenitic magma, as can be seen by the following calculation:—

[1] R. Daly, "Origin of the Augite-andesites": Jour. Geol., 1908, p. 409.

[2] Holmquist, "Studien über die Granite von Schweden": Bull. Geol. Inst. Upsala, vii, 1906.

[3] H. S. Washington, "Chemical Analyses of Igneous Rocks published from 1884 to 1900": U.S. Geol. Surv., Prof. Pap. No. 14, 1903.

[4] R. Daly, "Average Chemical Composition of Igneous Rock-types": Proc. Amer. Acad. Arts and Sciences, xlv, No. 7, p. 209, 1910.

TABLE III.

	Molecular Ratios.		
SiO_2	1·013		
Al_2O_3	0·165	0·180	
Fe_2O_3	0·015		
FeO	0·056	0·275	0·351
MgO	0·112		
CaO	0·107		
Na_2O	0·049	0·076	
K_2O	0·027		

$3·5\ \bar{R}O\ 1·8\ R_2O_3\ 10·1\ SiO_2$ or $1·95\ \bar{R}O\ R_2O_3\ 5·62\ SiO_2$

$\alpha = 2·27 \quad \beta = 52 \quad \gamma = 1·90.$

$R_2O : RO = 1 : 3·6.$

Syenite : $1·8\ \bar{R}O\ R_2O_3\ 5·6\ SiO_2$.

$\alpha = 2·4 \quad R_2O : RO = 1 : 2·2.$

Diorite : $1·5\ \bar{R}O\ R_2O_3\ 4\ SiO_2$.

$\alpha = 1·77\ R_2O : RO = 1 : 4·3.$

Thus the average composition of the igneous rocks (probably of the entire outer part of the crust) corresponds nearly to the syenitic magma. Is this to be interpreted as meaning that the primordial magma is in reality a syenitic one? Such a conception exists, but we can oppose to it several geological data and petrogenetic considerations. If the syenitic magma were really the fundamental magma, from which were derived and are still derived all the other types of igneous rocks, we should expect that this magma would have a great development, that it would be represented by definite plutonic and volcanic regions, and that the eruption of granites, gabbros, and other 'derived' rocks would be preceded by an eruption of the fundamental magma. Observation does not confirm these suppositions. The syenitic intrusive bodies are generally of far smaller dimensions than the masses of granitic or gabbro-peridotitic-pyroxenitic formations; the syenites are often only a marginal facies (*Randfacies*) of these two formations. In regard to the well-known syenite of Plauen this connexion with the Meissen granite, and the subordinate position of the syenite, have been pointed out by Rosenbusch, and, as far as I can see, all syenites are only local facies of a granitic or a gabbroidal formation.

Were the syenitic formation the fundamental magma, and the other rocks derived from it, we should expect it to afford proofs of differentiation which we do not find, because the syenite is itself a derived magma, generated by one of the two above-mentioned formations, which show various processes of differentiation. The figures on Tables I and II demonstrate also that Rosenbusch was not right in considering that the monzonites and essexites represent the average composition of the terrestrial magma. Rosenbusch says,[1] speaking of the monzonites: ". . . dass sie zusammen mit den Essexiten ziemlich genau mit dem terrestrischen Gesammtmagma chemisch übereinstimmen," and further: ". . . Diese beiden Gesteinsfamilien [the monzonites and the essexites] stellen, um die

[1] H. Rosenbusch, *Mikroskopische Physiographie der massigen Gesteine*, 4th ed., pp. 142, 395, 1907.

wichtige Thatsache noch einmal zu betonen, die reinste ungespaltene Form des tellurischen Magmas dar. Darin liegt ihre hohe Bedeutung." He emphasizes also his opinion that the monzonitic magma is subject to large differentiation processes.

The following calculations show clearly that the monzonite and the essexite differ more from the average magma than the syenite:—

TABLE IV.

Monzonite (after the latest calculations of Daly)—

	%	Molecular Ratios.		
SiO_2	56·74	0·946		
Al_2O_3	16·97	0·166	0·185	
Fe_2O_3	3·11	0·019		
FeO	4·64	0·064		
MgO	4·31	0·108	0·282	0·383
CaO	6·12	0·110		
Na_2O	3·57	0·057	0·101	
K_2O	4·22	0·044		

$3·8\ \bar{R}O\ 1·9\ R_2O_3\ 9·5\ SiO_3$ or $2·07\ \bar{R}O\ R_2O_3\ 5·11\ SiO_2$.

$\alpha = 2·01.\quad R_2O : RO = 1 : 2·8.$

Monzonites after Brögger[1]—

$2·34\ \bar{R}O\ R_2O_3\ 5·05\ SiO_2.$

$\alpha = 1·91.\quad \beta = 55.$

$R_2O : RO = 1 : 3·3.$

We can readily see that this magma is not more like the average one than is that of the syenite; the average magma is rather the mean between the monzonitic and the syenitic magmas (except as regards silica and the relation $R_2O : RO$). This magma in reality much resembles that of the syenite, and if we take my earlier formula for the gabbro-syenites (= monzonites), the difference between this magma and the average will appear even more evident.

The essexitic magma presents even less resemblance to the average terrestrial magma, as can be shown by the following calculations:—

TABLE V.

Essexite (after the latest calculation of Daly)—

	%	Molecular Ratios.		
SiO_2	50·02	0·834		
Al_2O_3	17·58	0·172	0·206	
Fe_2O_3	5·38	0·034		
FeO	6·50	0·090		
MgO	4·72	0·118	0·340	0·439
CaO	7·40	0·132		
Na_2O	4·68	0·075	0·099	
K_2O	2·23	0·024		

$4·4\ \bar{R}O\ 2·1\ R_2O_3\ 8·3\ SiO_2$ or $2·1\ \bar{R}O\ R_2O_3\ 4\ SiO_2$.

$\alpha = 1·58.\quad R_2O : RO = 1 : 3·4.$

This magma corresponds to the vogesitic magma, and approximates to the syenito-dioritic one, but is very different from the terrestrial average.

[1] W. Brögger, *Die Eruptivgesteine des Kristianiagebiets.* II. Die Eruptionsfolge der triadischen Eruptivgesteine bei Predazzo. 1895, p. 27.

Rosenbusch notes that the monzonitic and essexitic magmas are subject to large differentiation processes; this assertion, however, cannot be considered as correct, because the monzonites are one of the products of the largely differentiated gabbro-syenitic magma, but are not sensibly subject to differentiation.

Our conclusion is then the following:—Not one of the magmas, syenitic, monzonitic, or dioritic, can be considered as the primordial magma, from which were derived and are still derived all eruptive rocks. And not nearer to the truth are those who urge that the primordial magma is either a granitic or a basaltic one. Thus Mennell [1] criticizes the calculations of Clarke and others, and is quite right in objecting to their calculations, as they ought to have taken into consideration the relative quantities of the different types of igneous rocks. His own calculations for a part of Rhodesia lead him to support the view of a granitic magma; presuming that the granitic rocks equally predominate in all other countries, he is logically induced to consider the granitic magma as representing the primordial terrestrial magma. But the predominance of granitic rocks is certainly only apparent. For Sweden we have calculations which demonstrate that the granitic and the basic rocks are represented in nearly equal quantities; and such calculations would certainly give the same result for many other countries, where granites seem to predominate. And if in such parts of the globe as Finland the granitic rocks really or apparently predominate, there are other districts, as the Ural Mountains, where the predominance is certainly on the side of the different members of the basic magma, the gabbro-peridotitic-pyroxenitic magma.

What has been said of Mennell's hypothesis, is in full measure applicable to the basaltic magma, the antipodes of granite. Daly, who, as has been mentioned above, considers the terrestrial average to be a 'dioritic' magma, formerly expressed another point of view. In 1903 [2] he regarded as the universal earth magma the basaltic (gabbroidal) magma, and pointed out that the other eruptive rocks are derivates, produced by abyssal assimilation and magmatic differentiation. This opinion was supported by the following facts:—The fissure-eruptions and the other cases of eruptions on a great scale are represented by the basalts; the basalts and andesites have a much wider distribution than other volcanic rocks; the last products of eruption (when the primordial magma is not further influenced by assimilation) are basaltic rocks (p. 110).

Dutton [3] has expressed similar ideas; he also considers the basalts as the 'primordial matter', and infers that the other types of volcanic rocks are the result produced by a refusion of sedimentary formations. But are the basalts and andesites really predominant amongst the volcanic formations? A definite and exact answer to this question

[1] F. P. Mennell, "The Average Composition of the Igneous Rocks," Geol. Mag., 1904, p. 263; "The Constitution of the Igneous Rocks," ibid., May, 1909, p. 212.

[2] R. Daly, "The Geology of the Ascutney Mountains, Vermont": Bull. U.S. Geol. Surv., No. 209, 1903.

[3] Dutton, *The High Plateaux of Utah*, 1880, p. 125 (cited after Daly).

is at present difficult, indeed a satisfactory solution of the problem is probably not yet possible. We must remember that to the Silurian and Devonian diabases and melaphyres, we can oppose the Carboniferous and Permian porphyries, and that in the Archæan and Algonkian formations the porphyries, keratophyres, and porphyrides have an equal or even a larger development than the basic eruptions. The Tertiary fissure eruptions belong of course to the basaltic formations; but we know so little of the Jurassic and Cretaceous eruptions, and what would they tell us? We must not forget the trachytic, dacitic, and liparitic eruptions of the Tertiary, and we must also take into consideration that the basalts and andesites are not always the last products of eruption. If we also remember the before-mentioned quantitative relations between the granitic and the basic intrusives, we must confess that there are not sufficient data for considering the basaltic magma as the most widely developed one, and as representing the primordial and average terrestrial magma.

If we summarize all that has been said hitherto, we arrive at the conclusion that the average composition of the terrestrial magma does not correspond to a syenite, nor to a monzonite or essexite, a diorite, a granite, or a basalt (gabbro). Moreover, every hypothesis which regards the average terrestrial magma as corresponding to one definite eruptive rock and assumes only one primordial magma, from which all eruptive rocks are to be deduced, is erroneous; such a hypothesis could hardly be made to explain in a satisfactory manner all the peculiarities of distribution and the genetic relations of all eruptive rocks.

The mutual relations of the eruptive rocks may be explained most satisfactorily by the admission of two primordial magmas: a granitic and a gabbroidal (basaltic) one. In what way these two magmas have been generated and how they are distributed in the earth's crust, is a question that may remain open meanwhile. We take it as a fact that there must be admitted two independent primordial magmas, and only these two magmas, while all other eruptive rocks are derivates from them, originating by assimilation and differentiation. Such a hypothesis is based on the following facts and considerations.

1. Two primordial magmas of granitoidal and gabbroidal composition, entering into the composition of the solid crust nearly in equal quantities, give just the average composition of this crust which has been found hitherto by the calculations of different authors.

2. The different members of the granitic formation and the gabbro-pyroxenitic-peridotitic formation occur in much larger bodies and have a far greater development than the other eruptives. We know very large gabbro-noritic intrusive bodies which are often accompanied by a more or less varied series of differentiation products (pyroxenites, peridotites, anorthosites, and different vein- and dyke-rocks), but are quite independent and not connected with other intrusives: I can cite, for instance, the gabbro-formation of the Ural Mountains. We know also in several countries extensive and independent granitic bodies. On the other hand, the other rock-types form far less extensive bodies, have a smaller development, and occur generally as marginal or other facies of the granitic or gabbroidal formation. Thus the syenites are

closely connected with granites, forming a facies of these latter; the alkaline syenites are connected with alkaline granites; the diorites partly with the granites and partly with gabbros and norites. The quartz-diorites are of course largely developed, but they are connected petrographically and geologically with granites in such way that we might speak of a granito-granodioritic formation as we speak of a gabbro-pyroxenitic-peridotitic formation. The connexion between the pyroxenites, the peridotites, and the anorthosites with the gabbro formation has been already referred to. The gabbro-syenites (=monzonites) are equally derivates of the gabbro formation; such rocks as adamellites, shonkinites, missourites, etc., are evidently also facies of other regionally independent rocks. There remains one rock-type whose position was not clear to me, and which seemed to present a difficulty to my hypothesis of only two individual and independent magmas, the granitic and the gabbro-noritic—I mean the nepheline-syenites. But since Beljankin's[1] researches in one of the important regions, in the Ilmen Mountains of the Ural, have demonstrated the connexion of the nepheline-syenite (miaskite) formation with the granites, and Daly[2] has developed the view in a recently published paper that all the nepheline-syenites are derivates from granites, this last objection to my conception of only two independent magmas is removed.

As the effusives represent the same chemical types as the intrusives, all that has been said before of the intrusive rocks is also applicable to them.

3. The original independence of the granitic (including the granodioritic) and of the gabbro-pyroxenitic-peridotitic formations is further corroborated by the fact that they are generally more or less differentiated and rich in facies and in diaschistic veins and dykes. The differentiation of these formations is quite natural if they are considered as original primordial magmas, as well as the absence or small degree of differentiation that is characteristic of such rocks as syenite, diorite, and monzonite, which are themselves differentiation products.

4. Another fact corroborating the original independence of the granitic and the gabbro-noritic formations is the absence of such transitional types as would speak for the production of one of them from the other through differentiation. Amongst regions well known to me personally, I can cite the Caucasus and the Ural Mountains, where these two formations are nearly equally developed and quite independent of one another, and where I have not found transitional types between the two formations in question. On the other hand we know from the studies of Harker[3] that where the granitic magma is mixed with gabbro there are formed such

[1] D. Beljankin, "Petrographical Sketches of the Ilmen Mounts," ii: Ann. Inst. Polyt. St. Pétersbourg, vol. xiii, p. 715, 1910.

[2] R. Daly, "Origin of the Alkaline Rocks": Bull. Geol. Soc. Amer., vol. xxi, p. 87, 1910.

[3] A. Harker, *The Natural History of Igneous Rocks*, 1909. Amongst different papers of the author cited in this work see especially "The Tertiary Igneous Rocks of Skye" (Mem. Geol. Surv., 1904).

transitional rocks (Harker's 'marscoite'), to which he gives the very suggestive name of 'hybrid' rocks, showing that their abnormal composition is due to mixture and not to differentiation. The evidence of admixture, the intrusion of one of the rocks into the other in small veins and veinlets, the occurrence of xenoliths of the one in the other, are, in my judgment, facts corroborating the original independence of the two magmas. Were the granite and the gabbro the result of differentiation from another original neutral magma, there would not be evidence of mixture. A very instructive case of identical relations between granite and gabbro is described by Philipp in his recently published study on the granites of the southern Schwarzwald.[1] The members of the gabbro-formation (Philipp's 'gabbroides') occur in separate intrusive bodies and also in xenolithic masses of varying size included in the granitic bodies; while between the granite and the gabbro there is a transitional zone of a mixed gneiss ('Amphibolmischgneiss'), produced by the mixture of the two formations. These data testify to the individuality of the gabbroid and the granitoid magmas, and to their different age. These facts sustain the hypothesis of assimilation, and exclude the presumption that the granites and the gabbroides have been formed by differentiation from a common neutral magma.

Rosenbusch cites of course, according to Lossen, the gabbros and diorites of the Brocken as an example of granitic facies; but my short visit to the gabbros of Harzburg and the Radauthal leads me rather to the conception that these gabbro rocks and the Brocken granites belong to different intrusive bodies connected by intermediary rocks, originated not by differentiation but by assimilation—a view which seems to be supported by the granophyric facies of the gabbro.

The conclusions at which we have arrived is not new. It is well known that as early as 1851 Bunsen[2] was led, by the study of the igneous rocks of Iceland, to the conclusion that they originated through the mingling of two primordial magmas—the normal trachytic (corresponding to our granitic) and the normal pyroxenitic (corresponding to the basaltic). And although the hypothesis that all igneous rocks must be considered as different mixtures of these two is now untenable, the conception that there are two primordial magmas and not one is certainly right. Michel-Lévy[3] has also supported the conception of two magmas. It is true that the two magmas of Michel-Lévy have a far more hypothetical character, and are somewhat indefinite and arbitrary. The alkaline magma comprises the granites as well as the nepheline-syenites, rocks of very different acidity; the magnesian magma is considered to correspond to the peridotites, the lamprophyres, and several other rocks. But even though the exposition of the two magmas of Michel-Lévy is not

[1] H. Philipp, "Studien aus dem Gebiete der Granite und umgewandelten Gabbro des mittleren Wiesentales": Mitteil. Badisch. Geol. Landesanst., vi, i, 1910.

[2] R. Bunsen, "Ueber die Processe der vulkanischen Gesteinsbildung Islands": Pogg. Ann., lxxxiii, p. 197, 1851.

[3] A. Michel-Lévy, "Sur la classification des magmas des rockes eruptives": Bull. Soc. Géol. France, xxv, 1897.

happily stated, from my point of view, the idea itself, that we must admit the existence of two independent magmas from which all igneous rocks originated by differentiation and assimilation, seems to be a true one.

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

III.—On the Structure and Evolution of the Phyllodes in some Fossil Echinoidea.

By Herbert L. Hawkins, B.Sc., F.G.S., of University College, Reading.

(PLATE XIII.)

In all the Regular Echinoids, with the exception of the Cidarids, and in the Irregular Echinoids other than the Clypeastroids and Spatangids, there is a tendency for the ambulacral plates to become crowded together as they approach the margin of the peristome. This is the inevitable result of the continuous formation of fresh plates at the edges of the oculars in the apical system, and their less rapid resorption at the opposite extremity of the ambulacrum. The compression of the ambulacral plates results in a crowding of the pore-pairs in the peristomial region, and this character seems to serve a sensory as well as a motor purpose.

In the Regular Echinoids the muscular effort of mastication is liable to raise the whole body, supported on the teeth, away from the surface on which the food is lying, and so the presence of an increased number of adhesive podia around the mouth is a feature of considerable advantage. Among those forms of the Edentate Irregular Echinoids which are not provided with a labrum, the importance of keeping the mouth firmly applied to the food-bearing surface is yet more urgent, and the increase in the number of the peristomial pores becomes proportionately greater. At the same time, it is necessary that some sensory power should be developed in this region, so that the animal may get an estimate of the quality and character of the food supply. For this function some of the podia would appear to be specialized. In the Spatangids, for instance, the specially large pores round the peristome give exit, according to A. Agassiz (1872, p. 697), to podia with ragged ends. As these cannot exercise an adhesive influence, they may well be sensory in function.

In the Cassidulidæ there is a peculiar series of structures, termed the *floscelle*, which occurs around the peristome. It is composed of five interradial *bourrelets* and five radial *phyllodes*. The bourrelets are formed by the narrowing and thickening of the interambulacra, which form knob-like processes, sometimes slightly overhanging the peristome, and probably homologous in function with the labrum of Spatangids. The phyllodes are expanded, often depressed, leaf-like regions of the ambulacra, and in them there is always some crowding of the pore-pairs. Cotteau (1869, p. 119) states that the size of the phyllodes is in direct proportion to the size of the petals on the adapical surface. This generalization, although in accord with the features of Oolitic forms, is not wholly accurate when applied to Cretaceous and later genera. A plan of the arrangement of the pores in the phyllode of a recent *Echinolampas depressus*, Gray, in my collection is given in Pl. XIII, Fig. 1. The pores are seen to be roughly triserial in arrangement, but the innermost member of each triad is considerably separated from the other two. In *Echinolampas* the pores are single. In some genera (e.g. *Catopygus*) only the inner series contains single pores, the outer two series being composed of pore-pairs. Although I have been unable to find any evidence on the subject, I consider it at least possible that the inner series of single pores may represent sensory tentacles, while the closely crowded pore-pairs of the outer series give passage to ordinary adhesive podia.

Although the arrangement of the pores is usually easily traceable, it is commonly very difficult to distinguish the plate-sutures near the peristome. By a process seemingly analogous to the obliteration of sutures in the skulls of adult vertebrates, these earlier-formed ambulacral plates tend to become very closely united. Perhaps the mechanical crushing which takes place in the adoral parts of the ambulacra may contribute to this effect. In fossil forms the difficulty is often enhanced by the development of crystalline cleavage-cracks, and accidental fractures. A certain type of weathering, by which the surface of the test is destroyed and all the sutures widened, is serviceable in some specimens, and in default of this a microscopic section will, when viewed under crossed nicols, indicate the position of the separate plates by the varying orientation of the calcite of which they are composed. In every case it is essential that the suturing be studied near the outer surface of the test, as there is often a considerable difference in the degree of plate-crushing developed on the inner and outer regions, that of the inner being usually less pronounced.

The arrangement of the pore-pairs and the tendencies of the plate-crushing are definitely triserial in the peristomial regions of all the forms I have examined, whether recent or fossil. This arrangement is particularly interesting in view of the fact that the plate-crushing in the Holectypoida, the most primitive group of Irregular Echinoids, is always triserial, in whatever part of the ambulacra it may occur. I have recently described this feature in outline (Hawkins, 1910, p. 349), and this paper may be regarded as a sequel to that research. The notation of the plates used here in the descriptions and diagrams is the same as that employed in the paper referred to, and the diagram there given is copied, with additions, on Pl. XIII, Fig. 2.

The phyllode is usually regarded as a structure restricted to the Cassidulidæ (including the Nucleolitidæ), but this is only true of its most complete development. Wherever, in Irregular Echinoids, the pore-pairs show a tendency to become triserial towards the peristome, the elements of phyllode structure seem to be present (e.g. *Conulus*). From the simple and incipient compression of the ambulacral plates in *Pygaster*, every degree of complexity of structure is traceable up to such an elaborate phyllode as that of *Catopygus*. Only in the Clypeastroids and Spatangids (among Irregular Echinoids) is no tendency to phyllode development to be found.

Certain characteristic stages in the formation of phyllodes will now be described, and then the phylogenetic significance of its development will be discussed.

Pygaster semisulcatus (Phill.). Pl. XIII, Fig. 3. Inferior Oolite.

Although not a Cassidulid, and possessing no true phyllode, *Pygaster*, the earliest of the Irregular Echinoids, shows the primitive condition from which this structure was evolved. The ambulacrum tapers gently towards the mouth, but occupies a considerable part of the margin of the peristome. The ambulacrals remain simple primaries from the apex to a point on the adoral surface about half-way between the ambitus and the mouth. There are sometimes slight traces of a sub-petaloid differentiation of the pores on the adapical surface. When the plate-crushing commences it follows the usual Holectypoid plan, every third plate gradually becoming a demiplate. This is plate *c* (see Pl. XIII, Fig. 2). In this way plate *a*, below the demiplate, makes up a larger part of the perradial suture than before, and appears proportionately narrower towards the interradial margin. Plate *b* remains practically unaffected, and the resulting appearance of the ambulacrum is somewhat like that of the greater part of the ray of *Conulus*. There is a tendency for the pore-pairs to become rather widely spaced in the peristomial parts of the ambulacrum in *Pygaster*, and they rarely show any departure from a uniserial arrangement. The traces of displacement which they may exhibit result from a slight perradiad shifting of the pores of plate *a*, those of demiplate *c* becoming more approximated to the interradial margin of the ambulacrum.

Galeropygus agariciformis (Forbes). Pl. XIII, Fig. 4.
Inferior Oolite.

Galeropygus marks a considerable advance on *Pygaster* in the progress towards irregularity. The ambulacra, which remain apetaloid throughout, are very much narrower in proportion, and, owing to the small size of the peristome, taper considerably in their adoral parts. Perhaps on account of this lateral compression the vertical plate-crushing is carried to a further extent than its contemporary. The first reduction of plate *c* takes place in a position similar to that in *Pygaster*, but almost before this plate becomes a demiplate the interradiad extension of plate *a* becomes pinched to a narrow strip. In some cases it is entirely cut off from the interradial margin, and plates *b* and *c* meet round it. In the more extreme cases plates *a* and *c* are almost on the same horizon, and together form a rough parallelogram, with a diagonal sloping interradially and adorally. This crushing, which is the true phyllode structure in a simple form, becomes reduced in intensity near the margin of the peristome, where the plates usually become somewhat irregular primaries. The pore-pairs take on a decidedly triserial arrangement. The pores of plate *a* are, by the more or less complete atrophy of the interradiad portion of the plate, compelled to take up a position which is often nearer to the perradial than to the interradial suture. The pores of plate *b*, as if in sympathy, move inwards to about half this extent, while those of demiplate *c* are perforce retained in their usual marginal position. A triad is thus composed of the pore-pairs of plates *a*, *b*, and *c* in descending order. *Galeropygus agariciformis* has all the essential features of phyllode structure, although the ambulacra are neither expanded nor depressed.

The genus in this, as in many other features, shows a close affinity with the Nucleolitidæ, the only important difference being the absence of any sub-petaloid development of the adapical regions of the ambulacra.

Trematopygus faringdonensis, Wright. Pl. XIII, Fig. 5. Lower Greensand.

Although this sub-genus is separated from its Jurassic relatives by a very great interval of time, yet, in default of satisfactory specimens of any of the *Echinobrissi* from the Oolites, I have chosen it as a representative of the Nucleolitidæ (Echinobrissidæ). From the scanty traces of sutures that I have been able to discern in *Echinobrissus scutatus* from the Corallian, there does not seem to be any essential difference in the ambulacral structures. The peculiar character of the incrustation upon the fossils from the dark-red beds of the Faringdon Sponge-gravels renders the sutures, however fine they may be, readily traceable.

There is no appreciable expansion of the ambulacra towards the peristome, and only a trifling amount of depression. The adapical portions are sub-petaloid, but from the apical system to some distance beyond the ambitus the plates are primaries of varying vertical diameter. The actual crushing-point is postponed until a slightly later position than in *Galeropygus*, but anticipatory demiplates (usually of series *c*) sometimes appear spasmodically, though they never occur on the adapical surface. Where the pore-pairs become definitely triserial, the plates are crushed in a manner exactly comparable with that described in *Galeropygus*, but plate *a* is sometimes separated from the interradial margin by a considerable space. A corresponding simplification of the structure is seen in the immediate vicinity of the peristome.

Galeropygus and *Trematopygus* may, judging by the somewhat scanty evidence I have been able to find in other genera, be taken as representing the typical condition of phyllode development in the Nucleolitidæ. On the analogy of the term sub-petaloid as applied to the adapical regions of ambulacra, I suggest the term *hypophyllodal* to express the condition of the adoral parts of ambulacra which have the true phyllode structure as regards their plating, but which are not expanded or depressed.

Clypeus ploti, auct. Pl. XIII, Fig. 7. Inferior Oolite.

The most striking distinctions between *Clypeus* and *Galeropygus* are found in the extreme petaloid character of the adapical parts of the ambulacra in the former, coupled with the development of a marked floscelle with prominent bourrelets and broad phyllodes near the peristome. In *C. ploti* the ambulacrals retain their primary character until the expansion for the phyllodes begins. Then plate-crushing rapidly supervenes; but, although plate *c* is the first to become compressed, it rarely altogether becomes reduced to a demiplate, while plate *a* becomes almost, if not quite, separated from the interradial margin from the first. Apart from the persistence of the primary character in plate *c*, the plating is quite similar to that in the hypophyllodal forms already described. There is, however, an advance in the manner of distribution of the pore-pairs. They are triserial, in the order *a*, *b*, *c*; but, while the pairs of *b* and *c* follow the outline of the phyllode more or less definitely, series *a* passes in a straight line, from the point where expansion of the ambulacrum begins, to the corners of the ambulacral margin of the peristome. Thus, in the widest part of the phyllode, these pore-pairs are distinctly separate from the marginal series. They exhibit no difference in size or proportion from the outer pairs.

Clypeus hugi, Agassiz. Pl. XIII, Fig. 6. Inferior Oolite.

The phyllodes of this species differ from those of the last only in their greater expansion. The plating is as nearly identical with that in *C. ploti* as can be expected, and the isolation of the central series (*a*) of pores is no more complete since the peristomial margins of the ambulacra are proportionately wider.

Pygurus michelini, Cotteau. Pl. XIII, Fig. 8. Great Oolite.

The genus *Pygurus* shows the development of the floscelle in a considerably advanced stage. The prominent bourrelets and broad concave phyllodes give a very beautiful appearance to the adoral surface in all the species of the genus. On the adapical surface the ambulacra are broadly petaloid, but are uniformly composed of primaries. No plate-crushing appears until the broadening of the phyllode commences. The result is structurally very similar to that in *Clypeus*, but in the course of their passage across the very wide ambulacra the plates undergo a modification which seems to have an important significance when the structure of the next form (*Catopygus*) is considered. Plate *c* hardly ever becomes an actual demiplate, but is connected to the perradial suture by a very narrow band. Similarly, plate *a* is rarely quite separated from the interradial margin. Its perradial portion is expanded in such a way that, besides reducing the vertical diameter of plate *c* to a very small amount, it exerts a considerable crushing influence on plate *b*, which thus becomes narrow perradially and proportionately broad interradially. In this way the perradial suture comes to be formed of the edges of plates of series *a* more than of those of *b* and *c* combined, while these latter series make up almost the entire interradial margin.

Catopygus carinatus, Leske. Pl. XIII, Fig. 9. Cretaceous.

The phyllodes in this species are the most complex in structure of any that I have seen. Unfortunately the small size of the specimens renders the tracing of the plate-outlines peculiarly difficult. The figure given is, after the manner of a composite photograph, generalized from a series of camera-lucida drawings taken from all five phyllodes in some nine or ten specimens. It may be further mentioned, in support of the figure's accuracy, that it was made before I had adequately studied the simpler types of phyllode, and so is the product of an unbiassed mind. The ambulacra are only slightly sub-petaloid on the adapical surface, so that Cotteau's assertion that complex phyllodes and broad petals are always associated does not apply to this case. The bourrelets are but slightly prominent, and the phyllodes are almost flush with the level of the adoral surface. The ambulacra, below the sub-petaloid tract, are composed of high primaries until the expansion for the phyllode commences, when plate-crushing rapidly develops, and the average height of the plates is reduced by more than one-half. Plates of series *a* are the first to suffer, and they become separated almost at once from the interradial margin. Plate *c* is immediately afterwards crushed to a demiplate, and the perradial portion of plate *b* is constricted, as in *Pygurus*. The crushing is accelerated to such a degree that the '*Pygurus*-phase' of the structure persists for not more than two of the triple sets of plates. Then plate *a* becomes notably high, and extends laterally less than half the distance to the interradial margin, while not only plate *c*, but also *b*, become reduced to the condition of demiplates. The resulting structure is more apparent from the figure than it could be rendered by description. The phyllode appears as if it were made of two distinct ambulacra, one within the other; the inner of more or less hexagonal plates, and the outer of twice as many long narrow plates. Here and there a slight irregularity in the degree of crushing gives the clue to the origin of this peculiar structure. At about the middle of the phyllode, one of the central series of *a* plates on each side reaches out towards the interradial margin in every example that I have examined. The triserial arrangement of the pore-pairs is hardly appreciable, as the pores of plate *a* are so far distant from those of plates *b* and *c*, which are closely approximated. Moreover, the pores of the separate series are not altogether similar in character. The marginal series of *b* and *c* are paired, and appear as minute circles, but the *a* series of perradiad pores are heterogeneous. The upper member of each pore-pair is unusually large, while the lower pore is excessively minute, and often quite invisible. It is in this case that the suggestion seems feasible that the outer pores are for the passage of normal podia, and the inner series for sensory tentacles.

The value of the phyllode in classification.—I have already indicated (Hawkins, 1910) that the ambulacral structures have as great a value in the classification of the Holectypoida as they have among Regular Echinoids. To a large extent the reliability of this feature in the cases mentioned may be ascribed to the fact that it is not one of vital importance to the individual. A multiplication of pore-pairs, similar to that found throughout the greater part of the ambulacra of both groups, could be attained without any interference with the primary character of the ambulacral plates. For this reason, the presence of so persistent a series of peculiarities as those found in the ambulacra of the various groups of Regulares and in the Holectypoida affords a useful criterion of affinity. In the case of the phyllode, the feature of adaptation to surroundings and manner of life is introduced. The urgency of some such provision in the case of edentate forms without labra has been emphasized at the beginning of the paper. But in this case it would seem that the ethological considerations cannot eclipse the fundamental phylogenetic evidence of the structure. One may regard the labiate mouth of a Spatangid and the floscellate mouth of a Cassidulid as being both adaptations to the same necessity.

(This analogy is supported by the presence of 'bourrelet'-like structures in such a genus as *Echinocardium*.)

As far as I have been able to examine the structures, and by inference from the arrangement of the pores in forms whose sutures were indistinguishable, I feel confident in asserting that all phyllodes have the same structure, and the same method of attaining it. In fact, wherever a departure is made from the uniserial arrangement of the pores in Irregular Echinoids (even in the peculiarly aberrant petaloid portion of the anterior ambulacrum in *Heteraster oblongus*), the sequence becomes triserial. When this fact is compared with the extreme differences in structure that Duncan has described in the Regulares (as may be exemplified by a comparison of a compound ambulacral of *Hemipedina* with one of *Strongylocentrotus*), the corollary seems obvious.

The Holectypoida and those Atelostomata grouped as Asternata (see Gregory, 1900, p. 320) form a homogeneous group which, whatever complexity of interrelation they may possess, must be traced back to a common ancestry. The triserial arrangement of the ambulacral structures lends further weight to the arguments given by Bather (1909, p. 106) for the belief that this ancestry is to be sought among the primitive Liassic or Triassic Diademoids. I hope to deal in a future paper with the relations of the various lines of descent which spring from the Holectypoid stock. This paper may be regarded as a preliminary to that more detailed study. Consideration of the other features, apart from ambulacral plating (which all seem to tend towards the same conclusions), must be deferred to the larger paper.

In the Holectypoida themselves, there is little advance in the tendency towards phyllode development until *Conulus* is reached in the Lower Cretaceous. In that genus the pore-pairs near the peristome become triserial, and an approximately hypophyllodal structure is attained. The genus *Pyrina* of the Echinoneidæ appears perhaps in the Jurassic in the form once called *Nucleopygus*, but it attains its chief importance in the Lower Cretaceous. To the embarrassing similarities between *Pyrina* and *Conulus* must be added the fact that the same method of plate-crushing obtains in both genera. The same remark applies to *Echinonëus*, so that the distinction between the Holectypoida and Echinoneidæ becomes wholly arbitrary, at least among their Cretaceous types. The recent discovery by Agassiz (1909, p. 490) of teeth in a young *Echinonëus*, and the description of the teeth of *Conulus* (Hawkins, 1911, p. 70), are further proofs of the close relationship that exists between the two groups.

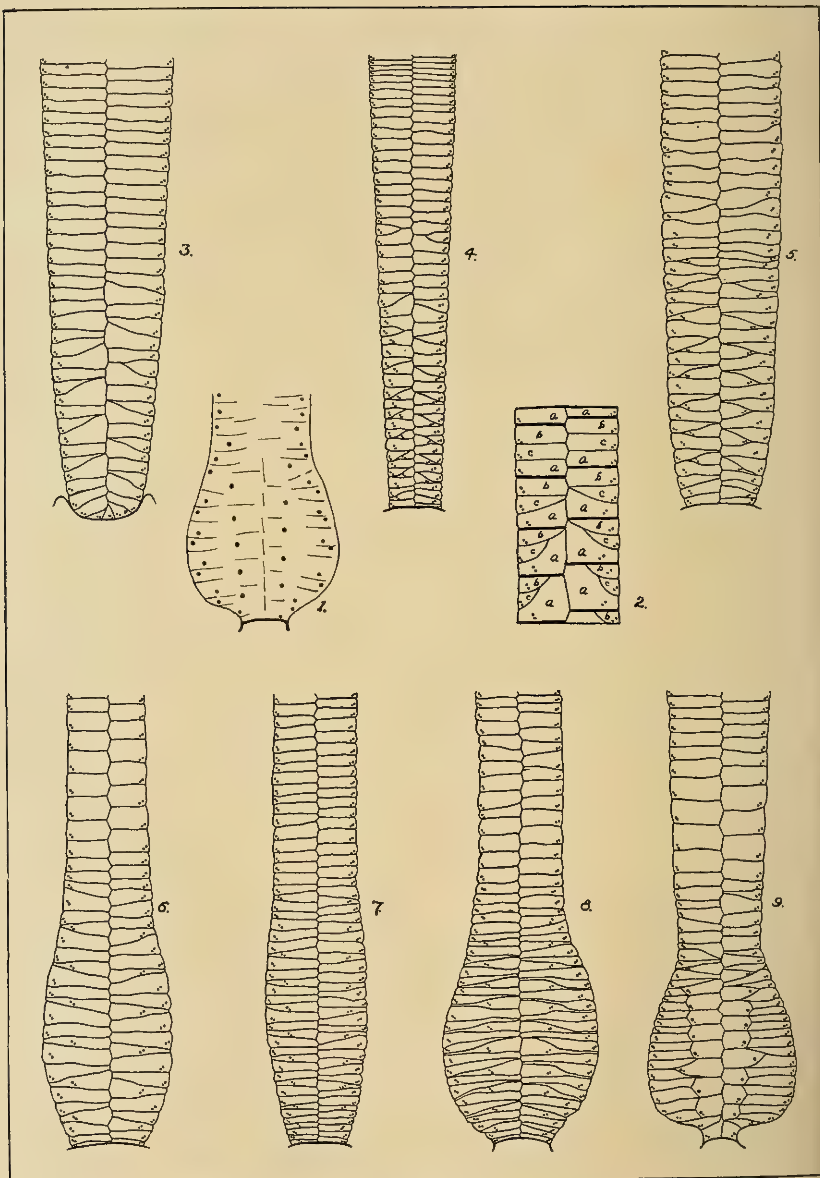
Galeropygus, of which the earliest known species occurs in the Upper Lias, may well be claimed as the ancestral form of all the non-Holectypoid irregular Echinoids except the Clypeastroids. From this genus there appears to have been a double line of descent. In one series the ambulacra become strongly petaloid, while a well-marked floscelle develops on the adoral surface. This series includes such characteristic genera as *Clypeus* and *Pygurus*, and attained its essential characters quite rapidly, *Clypeus* in particular being abundantly represented by characteristic species in the Inferior Oolite. The second series is one which retained the more primitive features of *Galeropygus*, with but slight modifications, for a much longer period. This was the family of the Nucleolitidæ (Echinobrissidæ), in which the ambulacra only attain a sub-petaloid condition adapically and a hypophyllodal condition adorally. *Echinobrissus* is a characteristic genus of this group. But while, as far as the evidence seems to point, the *Clypeus–Pygurus* group did not survive the Cretaceous period, the *Echinobrissus* group underwent fresh differentiation in that period, the petals becoming more pronounced and the phyllodes highly specialized. The resulting forms are typified by *Catopygus* and *Echinolampas*.

The product of this Cretaceous development from the Nucleolitidæ is so like that of the Jurassic descendants of *Galeropygus*, on the *Clypeus* line of descent, that both series have been grouped together as the Cassidulidæ. If the interpretation here indicated be correct, this family will need subdivision into, approximately, the Jurassic and Cretaceous Series respectively as distinct families, and would serve as yet another illustration of the principle of 'heterogenetic homœomorphy'. The heterogeneity is, however, more apparent than real, as the *Echinolampas* series is the outcome of the slow development of the *Echinobrissus* series, proceeding along the same lines as those more rapidly traversed by the cognate *Clypeus* series. In passing it is of interest to note that the group which quickly attained a high specialization of petals and phyllodes was comparatively short-lived, while the other group, which appeared at the same time, but which did not reach the *Clypeus* stage of ambulacral complexity until the Cretaceous period, is represented at the present day by members of its simple (*Nucleolites*) and complex (*Echinolampas*) sections.

There yet remains the problem of the origin of the Clypeastroids and Spatangids. In both these large groups some ambulacral plate-crushing occurs (e.g. in *Clypeaster*, *Arachnoides*, and *Echinocardium*), but it never occurs on the adoral surface and is not always triserial. I have reason to believe that this crushing in the petaloid parts of the ambulacra is a secondary development, independent in origin from that of the other Echinoids. The difficulty is encountered when one considers the simplicity of the ambulacra on the adoral surface, where surely the ancestor or ancestors of the groups must have possessed more complex structures. At present, although from other considerations the Clypeastroids seem to show affinity with such a form as *Discoïdea*, and the earlier Spatangids with the 'Cassidulidæ', I have found no evidence to indicate the way in which demiplates may be restored to a primary condition, and caused to undergo such remarkable changes in proportion as they show in these groups. Bather (1909, p. 107) discusses the problem with regard to *Orthopsis*, but comes to no definite conclusion. More evidence on the post-larval development of recent forms is necessary before this question will be ripe for solution.

In conclusion I wish to express my indebtedness to Dr. F. A. Bather, F.R.S., for his advice and assistance.

Summary.—The physiological value of the phyllode is considered to be both mechanical and sensory, and the structure of its plating



H.L.H. del.

Arrangement of plates in phyllodes of some Fossil Echinoidea.

is described in several characteristic genera. A distinction is drawn between phyllodal and hypophyllodal structures. A triserial arrangement of the ambulacral pores is shown to correspond with some degree of phyllode development. The importance of the structure from the point of view of classification is discussed. Emphasis is laid upon the close relationship between the Holectypoida and Echinoneïdæ. The Cassidulidæ are regarded as a composite group, divisible into two sections (roughly the Jurassic–Cretaceous and the Cretaceous–Recent groups), the former being direct descendants of *Galeropygus*, while the latter, from the same source, slowly attain the Cassidulid character through the medium of the Jurassic Nucleolitidæ.

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EXPLANATION OF PLATE XIII.

The figures are all slightly diagrammatic, and enlarged to the same size regardless of their relative proportions.

FIG. 1. Arrangement of pores in phyllode of *Echinolampas depressus*.
,, 2. Diagram of the principle of Holectypoid plate-crushing.
,, 3. Hypophyllode of *Pygaster semisulcatus*.
,, 4. Hypophyllode of *Galeropygus agariciformis*.
,, 5. Hypophyllode of *Trematopygus faringdonensis*.
,, 6. Phyllode of *Clypeus hugi*.
,, 7. Phyllode of *C. ploti*.
,, 8. Phyllode of *Pygurus michelini*.
,, 9. Phyllode of *Catopygus carinatus*.

IV.—A NOTE ON THE GEOLOGY OF THE LITTORAL OF THE GOLD COAST COLONY BETWEEN ELMINA AND SEKONDI, WEST COAST OF AFRICA.

By JOHN PARKINSON, M.A., F.G.S., ETC.

THE following note on the rocks of the shore-line of part of the Gold Coast Colony are a result of a short journey I undertook there in 1910. On that occasion I landed at Cape Coast Castle and travelled westward, staying successively at Elmina, Chama, and Sekondi.

Starting along the coast at Elmina, the coarse granitoid gneiss of Cape Coast Castle, a rock rather poor in ferromagnesian minerals, is left behind at a point some two miles to the east, and is replaced by red grits or arkoses, which have a slight dip to the westward. These beds have frequent ironstone partings, two or three inches in thickness, and are often cross-veined with a similar material; doubtless, therefore, this is a secondary structure due to the deposition, under favourable circumstances, of iron leached from the beds themselves. A typical example of the ordinary red grit was composed of about 50 per cent. of angular quartz-grains, the greater part of the remainder of felspar, twinned and untwinned, often kaolinized, and similar to the felspars of the surrounding crystalline rocks.

Thin laminæ of kaolin also occur at Elmina, and occasionally pebble beds. The series continues along the sea-front as a broken ridge, and about six miles from the sea, to the northward, rests on the edge of the granitic platform. Here the coast is characterized by isolated flat-topped hills, which appear clearly to owe their structure to marine erosion, and are separated by semi-marshy flats of blackish soil, crowded with shells and impregnated with salt. The shells disappear about three miles from the sea. In these flats the natives dig pits, which fill naturally with water. This on being heated yields the salt. A slight depression would thus reduce the littoral to a series of islands, arranged in rows, approximately parallel to each other and to the sea-front.

The crystalline rocks include a biotite-garnet-granite, with muscovite as an accessory mineral, and having associated with it an aplite, locally pegmatoidal. In this rock microcline and quartz are the two principal constituents, the latter mineral giving evidence of a slight amount of crush. Triclinic felspar is rare and shows, when noticed, symmetrical extinction angles of about 13°, but the twinning is, in many instances, very irregular and partial.

At *Chama*, both on the shore and in the town, a massive gneiss is admirably exposed, and amongst the many varieties is one conspicuously banded. Gneissose veins or dykes cross the foliation of this rock, and, in thin sections, are seen to be identical in structure and composition with the more acid bands. The banding has, in fact, been produced by the injection, in parallel 'sills', of an acid magma, along the foliation planes of a more basic rock. The rocks are of granulitic structure, and usually contain a few flakes of biotite, with sphene and epidote as rare accessory minerals. Untwinned felspar, presumably orthoclase, is common, and occasionally a considerable proportion of microcline. An acid plagioclase is subordinate. The basic part of the gneisses contains much biotite, in flakes occasionally 6 mm. in length.

Two and a half miles west of Chama I found a garnet-hornblende-biotite-gneiss, granulitic in structure and well foliated. Into this rock gneissose dykes are clearly intrusive, and differ only in unessential points from those of Chama itself. It seems clear that at Chama and in the neighbourhood we have a group of biotite-gneisses, of which the acid member is the later, and which are associated with intrusive biotite-granites, aplites, and pegmatites. The strike of the planes of foliation is approximately east and west true.

The *Prah River*, which empties into the Atlantic about a mile to the east of Chama, flows, as regards its lower course, through a well-graded plane of granites and gneisses.[1] These rocks first emerge from

[1] In 1908 the Prah broke through the strip of sand which, as in many West Coast rivers, extended almost entirely across its mouth and enclosed a lagoon. When I saw it in the spring of 1910 this had been repaired by the building-up action of the surf and stood some 15 feet above sea-level.

the alluvium at Krobo, but a short distance from the mouth, and again at Biposo, two and a half hours' journey by canoe, or roughly ten miles. Here occurs a pegmatitic granite, containing a few flakes of biotite, which make a foliation just discernible. Fine-grained 'pepper and salt' gneisses are also conspicuous, in which the content of biotite varies irregularly, producing locally a concretionary appearance. These rocks outcrop at intervals from the river-bed at low-water around the village of Dabuassi, but the best exposures are at the Falls. Here many varieties of gneiss occur, amongst them one containing biotite, subordinate green hornblende, and paler epidote. Quartz, exhibiting some crush shadows, preponderates amongst the colourless minerals, which include a little microcline, a good deal of untwinned felspar, presumably orthoclase, and rare triclinic felspar. Very coarse pegmatite veins and a fine-grained white biotite-granite are associated with the foliated rocks. The black coating, superficially somewhat resembling graphite, which covers these rocks, and effectually masks their structure, is exceedingly well developed at these Falls of the Prah.

Some three and a half miles from Chama (going west) the purple grits come on again in force, dipping almost due south. They are often green and mottled, as are our English slates in some parts of Cornwall, and, approaching Sekondi, are in turn again succeeded by a hornblende-gneiss, cut as before by an acid rock. The more basic type of the former consists for rather more than half its bulk of a green hornblende. A few flakes of elongated biotite, of earlier growth, cut these. The felspar, an acid to intermediate plagioclase, preponderates over the quartz, which, as at Chama, shows crush shadows. Biotite-hornblende-gneisses, in which the proportion of the two-coloured constituents varies considerably, come from the same locality. In these quartz is usually common, exhibiting crush shadows as before, and quartz vermiculé is locally conspicuous. Large orthoclases, often twinned, a little microcline, and triclinic felspars, having symmetrical extinction angles up to 15°, are normal, but, in regard to the last named, it is noticeable that the twinning is often partial. Sphene, apatite, specular iron, pyrites, and iron oxides are the usual accessory minerals.

It is clear that along this part of the Gold Coast littoral, a distance of approximately forty miles, we have—

1. A group of biotite- and hornblende-gneisses, associated with later granites, pegmatites, and aplites.

2. A series of purple grits laid down upon the eroded surface of the crystalline rocks.

3. Evidence of considerable later elevation of the coastline. This elevation, remarked upon by Ellis[1] and suggested by the present writer in the case of Western Liberia, is, in the same manner, clear around the mouth of the Sassandra River, and may tentatively be correlated with the local elevation of the Ijebu Beds of Southern Nigeria (Pleistocene) and Benin Sands (Late Pleistocene to Recent) of the same Protectorate.

[1] Ellis, *The Tshi-speaking Peoples of the Gold Coast of West Africa*, p. 2.

REVIEWS.

I.—A New Vulcanology.

ALBERT BRUN of Geneva may be ranked as one of the most remarkable of contemporary workers in science. At his own expense, and in the intervals of a business career, he has visited the volcanoes of the Mediterranean region, of the Canary Isles, of Java and Krakatoa, and, finally, of Hawaii. Much more than this, he has supplemented mere observation by carefully planned experiments, carried out both in the field and in the laboratory. For such investigations it was necessary that Brun, in addition to his skill as chemist, physicist and geologist, should possess a cool head and undaunted pluck. His simple story of the eruption of Semero, in Java, and the accompanying photographic plates are ample evidence that this condition is fulfilled. Alike as a scientist and as a sportsman Albert Brun is sure of a respectful hearing from British geologists.

And what has led this observer to undertake a self-imposed task of such magnitude? A discovery: the universally accepted aqueous theory of volcanoes broke down when critically tested in the classic region of the Mediterranean; a new vulcanology developed in the mind of the experimenter, and accordingly nothing would suffice but a personal investigation of representative volcanoes in other parts of the globe.

Brun has published many papers since 1901, for the most part in the *Archives des Sciences Physiques et Naturelles*, Geneva, but considering the novelty and importance of his results he is to be congratulated on having gathered his writings together into book form.[1] The material as now presented has been largely recast, and its arrangement is excellent. The whole is easy to read, and although there is no index there is a full table of contents. The photographic plates add greatly to the value and beauty of the volume, and unfortunately also to its price.

We shall now give a brief *résumé* of the matter dealt with in this exceptionally interesting book.

A few definitions of terms are followed by an account of methods employed in taking *temperatures* during the progress of laboratory experiments designed to reproduce volcanic phenomena under conditions favourable to exact observation. Four examples will suffice to illustrate the value of such experiments in fixing temperatures actually encountered in the field—

1. The lowest temperature at which any particular lava can flow at all is given in the laboratory by the temperature at which a thin plate of the same lava (in the same state of crystallization) begins to bend under its own weight.

2. The temperature at which 'ropy structures' form can be ascertained during the artificial production of like structures in a slowly heated block of the lava in question, subjected to a slight lateral pressure by means of a vice.

[1] *Recherches sur l'exhalaison volcanique*, by Albert Brun, Chemist, L.Sc.Ph. Sorbonne, D.Sc.Ph. (*honoris causa*) Geneva. A large quarto volume, 227 pages, 16 text-figures, 27 photographic plates, and 7 panoramas. Price 30 francs.

3. The maximum temperature of a lava containing phenocrysts is given by the melting-point of the most fusible among these phenocrysts (e.g. 1,230° C. in the case of the augite phenocrysts carried by the lavas of Stromboli and Etna).

4. The maximum temperature possible for a volcano is fixed by the '*explosion temperature*' of its magma, that is, by the temperature at which its magma emits gas sufficiently rapidly to undergo a sudden expansion. Acid lavas have a sharply marked explosion temperature; basic lavas, which are more fluid, begin to give off gas to an appreciable extent as soon as they soften, and by careful heating it is possible to avoid actual explosion.

The laboratory determinations of temperature referred to above can be supplemented in the field, and this becomes essential in the investigation of fumaroles. The methods employed in such cases are given in outline in the book.

The results of about seventy experiments dealing with the temperature constants of minerals are tabulated. In keeping with the almost aggressive self-reliance of the author the recent work of the American school is not taken advantage of; this is unfortunate, and one has to turn to the original papers to realize the following correspondences:—

Anorthite.	*Melting-point (°C.).*
From Idsu, Japan .	1,490, 1,510, 1,520 (Brun, 1902).
Synthetic . . .	1,544, 1,547, 1,550, 1,562 (Brun, 1904); 1,532 (Day & Allen, 1905).
Albite.	
From Viesch . .	1,250 (Brun, 1902).
Synthetic . . .	1,230 (the value obtained by extrapolation; no definite melting-point ascertainable, 'melting' being spread over a temperature interval of about 150° C.; Day & Allen, 1905).
Pseudo-Wollastonite .	1,515 (Brun, 1904); 1,512 (Allen & White, 1906).

These results show that Brun was much in advance of his time in the accurate determination of geophysical temperate constants. In other cases where comparison is possible there are somewhat important discrepancies; these are no doubt due in part to chemical peculiarities in the naturally occurring minerals experimented on by Brun, but their occurrence makes the omission of the American data all the more regrettable.

The results of thirty-five temperature experiments with lavas may be illustrated by giving two examples.

Kilauea. Basaltic glass with very few crystals. On account of this scarcity of crystals the lava is extremely fluid at moderate temperatures; at the same time, to obtain initial deformation one must heat to a higher temperature than in the case of lavas from other volcanoes: up to 1,100° C. the colloid is unusually resistant, but above this it becomes very fluid. According to different experiments the temperature of formation of a ropy surface is 1,072° C. or 1,073° C., and the temperature at which the lava flows freely with emission of gas is 1,116° C. or 1,159° C. The "hairs of Pélé" form at 1,120°–1,160° C.

Krakatoa. Green obsidian mixed with the pumice of 1883. The explosion temperature for any particular specimen is very well defined. For commonly occurring types the following values have been obtained: 826° C., 861° C., 877° C., 883° C., 886° C., 888° C., 896° C.

It is thus tolerably certain that the temperature of the Krakatoa magma in the paroxysm of 1883 was approximately 880° C.

A contrast which presents itself in the behaviour of rocks in general when heated allows Brun to divide them into two classes, the active and the dead. The active rocks include only comparatively recent, unoxidized, volcanic products; all other rocks are dead.

Active basic rocks when melted liberate gas and volatile salts, which latter condense to form white fumes. The liberation of gas and vapour often swells the molten mass to such an extent that it overflows the crucible, furnishing a miniature fuming lava-flow. By cooling and reheating it is sometimes possible to repeat this experiment several times. A block of the 1904 lava of Vesuvius was still 'active' after five such heatings.

Active acid rocks are much more violent when heated and give rise to veritable explosions.

Dead rocks, such as schist, granite, or gabbro, behave quite differently. On heating they give off gas, and then at a higher temperature melt quietly. There is no trace of the magnificent expansion characteristic of the active rocks.

The tremendous pressure developed on heating obsidian to its explosion temperature can be illustrated by performing the experiment on a piece of obsidian enclosed in a box of refractory steel. When the explosion temperature is reached the box is burst and the magma is extruded in a manner which recalls the formation of the spines of Montagne Pelée and Merapi (Java).

As a general rule a magma, at any rate when once it has been extruded at the surface, is markedly heterogeneous in regard to its gas-producing capacity. On a field of lava there are comparatively few points from which fumes issue in really great abundance. Again, certain thin bands in obsidian may flash up into froth on heating while other adjoining layers remain glassy.

The volume of gas liberated in exploding an obsidian can be ascertained approximately from a comparison of the density of the obsidian with that of the resultant pumice. To take two striking examples: Lipari obsidian of density 2·358 corresponds with a pumice of density 0·224; and Krakatoa obsidian of density 2·36 corresponds with a pumice of density 0·416. In the case of Krakatoa this means that 1 kilog. of the obsidian must yield 1,577 c.c. of gas at 880° C. (the explosion temperature), or 373 c.c. reckoned at 0° C.

Here Brun turns aside to give an account of the collection, extraction and analysis of the various volcanic gases.

Collection in the field. There are two main methods. Wherever possible the gases are pumped through a system of tubes, which may be made of lead where the temperature is low or of glass where it is high. A rubber pump is used, and the gases, once they are cooled down, are collected over mercury, or, as the case may be, examined in a hygrometric chamber. The glass tubes employed are each a metre long, and sometimes as many as forty of them have been connected end to end, their joints wrapped in sheets of lead or aluminium bound with iron wire. This method has the advantage of providing as much gas as can be stored. The glass tubes can afterwards be washed to allow of an estimation of the solid material of the fumes. Where haste is essential a vacuum tube can be carried to the desired point, and there opened, charged and resealed.

Extraction of gases in the laboratory. A vacuum apparatus is employed, and this, with the methods of gas analysis, is described in the book. Very numerous experiments show that such water as is given off is always liberated before the explosion temperature is reached; it is largely dissipated at 150° C.; at 300° C. there is none left. Certain old volcanic glasses are found to be exceptionally hydrous.

The main volatile constituents liberated from active rocks at the explosion temperature are—

Gases.—Chlorine, hydrogen chloride and oxides of carbon.

Solids.—Chlorides of the alkali metals of ammonium and to a small extent of ferrous iron.

Sulphur and its compounds are almost always inferior in amount to chlorine and the oxides of carbon.

Details of the volatile constituents extracted at the explosion temperature *in vacuo* are given for the lavas of about fifty distinct volcanoes, embracing every part of the earth. The relative proportions vary greatly, as will appear from the following table:—

		Stromboli.	Vesuvius.	Kilauea.	Semero.	Krakatoa.	Arran (Pitchstone).
Volume of gas in c.c. (0° C., 760 mm.) per kilog. of lava		266	397	295	139	498	457
NH_4Cl in mg. per kg.		13·5	17	12	20·5	49	45·7
Other volatile chlorides in mg. per kg.		243	3500	50	143·5	—	—
Hydrocarbons		—	—	very volatile	—	—	volatile
Per-centage volumes of each gas.	Cl_2	12·8	4·2	—	18·2	59·64[1]	absent
	HCl	2·0	trace	trace	9·2	11·63	5·8
	SO_2	4·5	3·35	1·7	absent	7·99	46·7 (SO_2, CO_2)
	CO_2	60·2	66·30	50·8	47·2	6·73	
	CO	11·47	26·15 (CO, CH_4, H_2, N_2)	17·3	18·0	4·78	18·2
	CH_4	1·60		—	—	—	—
	H_2	0·5		28·5	3·35	—	—
	N_2	6·93		1·2	3·35	8·73[2]	—
	O_2	—	—	—	—	0·50	—
	Fetid combustible residue	—	—	—	—	—	29·3
		100·0	100·0	99·5	99·3	100·0	100·0

[1] With traces of S_2Cl_2. [2] N_2 and other gases.

Water does not enter into the results given above, since these are wholly concerned with volatile matter released at the explosion temperature. The Arran pitchstone is regarded as a typical hydrated obsidian of moderate antiquity. It has much water, which it loses almost entirely at 200° C., whereas its explosion temperature is about 900° C.

It is important to realize that the anhydrous gases which are liberated from a lava heated *in vacuo* to its explosion temperature, are more than sufficient to explain the paroxysmal phenomena observed in nature. We have already seen that in the Krakatoa eruption of 1883 every kilogram of obsidian involved gave about 373 c.c. of gases (0° C. and 760 mm.). In the laboratory experiments 457 c.c. have been obtained, not to mention 45·7 mg. of ammonium chloride.

To bring these results into closer touch with nature is the next step. Brun finds that freshly fallen ashes contain soluble chlorides, including ammonium chloride and greasy hydrocarbons, which later can be extracted with chloroform. They also always give an acid reaction. It thus appears that the stony matter of the ashes is mixed with the same volatile products as are generated in the artificial distillation of a magma under anhydrous conditions *in vacuo*. Samples of the 1906 ash of Vesuvius, collected during the eruption at thirty-five different localities, contained from 1 to 1½ per cent. by weight of soluble salts, about equally proportioned between the sulphates and the chlorides. The abundance of sulphates is a feature of which no mention is made in connexion with the laboratory experiments.

The salts deposited by dry fumaroles and on the walls of craters are found to agree with those associated with ashes.

Secondary exhalation.—A specimen of lava, which has already been heated to its explosion temperature *in vacuo*, will give a fresh supply of gas if oxidized by heating to a moderate temperature in air or oxygen or by melting with some such reagent as *ferric oxide*. The gases produced under these circumstances constitute what Brun appropriately terms the secondary exhalation. A few examples are given in the subjoined table. It must be clearly understood that the secondary exhalations here tabulated are *additional* to the primary exhalations previously quoted.

		Stromboli.	Vesuvius.	Kilauea.
Volume of gas in c.c. (0°, 760 mm.) per kilog. of lava		512	643	62
Percentage volumes of each gas	Cl_2 . . .	trace	4·6	—
	SO_2 . . .	18·16	1·53	31·0
	CO_2 . . .	78·58	89·60	69·0
	N_2	3·26	4·27	—
		100·00	100·00	100·0

It may be pointed out that the emission of a secondary exhalation as a result of atmospheric oxidation does not necessarily entail any expansion at all, since carbon dioxide and sulphur dioxide occupy no greater volume than their contained oxygen.

Gas generators.—Brun suggests that the volcanic exhalations result in the main from reactions between silico-chloride of calcium ($Si\,O_3\;Ca_2\;Cl_2$), nitride of silicon and various hydrocarbons. Such speculations are of necessity unconvincing, but they are supported by a large number of strikingly interesting experiments. In regard to the origin of sulphur and its compounds in volcanic exhalations he expresses no definite view, but at the same time he has several important observations to record respecting the mode of occurrence of the element in nature.

An effect of high pressure.—The gases obtained experimentally *in vacuo* are the same as those which actually issue from volcanoes. There is only one exception: carbon monoxide, a characteristic gas of the laboratory experiments, is extremely rare in nature. Its absence may be accounted for on two heads. In the first place it is easily burnt to carbon dioxide on contact with air, and in the second place, according to Briner, it readily decomposes to carbon dioxide and carbon on heating to 300° C. at 600 atmospheres. It is quite possible, therefore, that the rarity of carbon monoxide in volcanic exhalations is due to the high pressures ruling during the emission of the latter.

E. B. Bailey.

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

II.—Canadian Geological Survey.

Reports on parts of the North-West Territories to the west of James Bay and south of Hudson Bay, have been prepared by Mr. W. McInnes and Mr. A. W. G. Wilson (1910). The rocks encountered during their explorations and traverses include Archæan, Lower Huronian (?), Silurian (Niagara), Pleistocene, and later deposits. A list of Silurian fossils obtained along the Winisk River is given on the authority of the late J. F. Whiteaves. Observations are recorded on the natural history, climate, archæology, etc.; and there are lists of recent land and freshwater mollusca collected by Mr. Wilson and named by Whiteaves.

The "Geology of the Nipigon Basin, Ontario", by Mr. Wilson (Memoir No. 1, 1910), is illustrated by a map containing a good deal of detailed work, as well as data obtained by traverses. The rocks are all grouped either definitely or doubtfully as pre-Cambrian. The greater part of the district is underlain by Laurentian gneisses and batholithic invasions of granite, which penetrate an apparently older series of greenstones and schists, classed as Keewatin. Infolded with the Keewatin rocks, and probably belonging to the higher portion of the series, is an Ironstone formation. The Keewatin Series also contains bands with quartz stringers and veins that yield small values in gold. These more ancient rocks are all intensely metamorphosed, and the prevailing structures are nearly vertical. Upon them rest the Keweenawan (Nipigon formation), consisting of conglomeraets, sandstones, shales, and dolomitic limestones. The later rocks are diabase, and they extend in patches over a large area.

A "Preliminary Memoir on the Lewes and Nordenskiöld Rivers Coal District, Yukon Territory", by Mr. D. D. Cairnes (Memoir No. 5, 1910), is descriptive of a varied series of formations, Pre-Ordovician, Devonian (?), Carboniferous (?), Jurassic or Cretaceous, Tertiary and Quaternary. Two horizons of coal are recorded in the Jurassic or Cretaceous; the higher beds, worked at the Tantalus mines, being the more valuable. The seams are from 3 to 7½ feet thick.

"The Edmonton Coal Field, Alberta," is described by Mr. D. B. Dowling (Memoir No. 8 E, 1910), and he estimates that, if mined economically, the available quantity of coal is about 80 million tons.

III.—Cleveland Ironstone and Iron.

MR. J. E. STEAD, F.R.S., read a paper before the Cleveland Institution of Engineers (Middlesbrough, 1910) on the Cleveland Ironstone and Iron. The author deals with the micro-structure of the Cleveland Stone, a subject illustrated by twelve photographic plates. Silica is present in the oolitic iron-ore in concentric layers, but no examples of oolitic limestone with silica envelopes could be procured, although the grains in the Pickering limestone of Corallian age contain much silica. Concentric layers of iron-pyrites (with nickel and cobalt) occur in the oolitic 'sulphur bed' of the Eston ironstone. A piece of petrified wood in the Eston ironstone contained 90 per cent. of calcium phosphate and 10 per cent. of a peat-like substance. In the Rosedale ironstone an ammonite was found in which the segments and outer shell had been considerably changed to ferrous carbonate.

In seeking for portions of the original rock Mr. Stead found what he believes to be a representative of it "imprisoned in the vertebral column of a *Plesiosaurus*". Analyses are given of the bone and of the substance inside it. That of the latter, which consisted of oolite closely resembling the ironstone itself, was as follows:—

	Dried at 212° F.
Ferrous Carbonate	15·58
Iron Pyrites	0·82
Alumina	7·00
Silica	19·80
Calcium Carbonate	51·16
Calcium Phosphate	2·53
Magnesia	1·67
Organic matter, etc.	1·44
	100·00
Iron	7·90
Sulphur	0·40
Phosphoric Acid	1·16

One of the oolite grains shown in pl. xii, and representing rock-material after treatment with hydrochloric acid, had evidently consisted mainly of calcite, but near the exterior there were to be seen a few concentric siliceous layers. Mr. Stead asks: "Does this single grain not indicate an uninterrupted change, and point to a process which, if continued, would have resulted in the complete replacement of the carbonate of lime by silica and ferrous carbonate? Considering the fact that the imprisoned substance contains an excess of carbonate of lime and very little ferrous carbonate, but in other respects corresponds to the analysis of the Cleveland ironstone, are we not justified in accepting the evidence as going far to prove that the original deposit was really siliceous and aluminous limestone, and that not only ferrous carbonate, but ferrous silicate in solution, has taken the place of carbonate of lime, as Dr. Sorby maintains, and that co-incidentally silica in solution has passed from the mass of calcareous and siliceous mud which surrounded the original, nearly pure limestone concretions, and was then deposited in concentric layers?"

IV.—Indian Geological Survey.

The Memoir on "The Geology of Northern Afghanistan", by Mr. H. H. Hayden, Director (Mem. Geol. Surv. India, vol. xxxix, pt. i, 1911), contains observations made "during a short tour undertaken primarily for the investigation of economic questions". The author describes the physical features and main geological structure of the country, and deals with a varied series of rock-formations. The age of the oldest, "Metamorphic and Crystalline Series," is practically undetermined, but it includes limestone, yielding ruby and rarely sapphire, and this may be of Devonian age. There is evidence of Lower Palæozoic rocks, of Devonian, Carboniferous, Permo-Carboniferous (Fusulina limestone), Triassic, Jurassic, Cretaceous, Tertiary, and Pleistocene. The facts gathered by the author, and previously by C. L. Griesbach (1880–8), lead to the conclusion that the "country is divisible into two stratigraphical provinces, one of which is represented only in Eastern Afghanistan, while the other comprises by far the greater part of the country and embraces most of the northern and western districts. The affinities of the former province are with the Himalayan area, whereas those of the latter are with Western Asia and also to some extent with Europe. The mutual separation of the two provinces seems to have taken place towards the end of the Carboniferous period". The memoir is illustrated by a geological map and many striking views of stratigraphical and rock features, including a recumbent fold, overthrusts, dome-structure, unconformities, etc.

V.—United States Geological Survey.

Bulletin 433, 1910, consists of a report on the "Geology and Mineral Resources of the Solomon and Casadepaga Quadrangles, Seward Peninsula, Alaska", by Mr. P. S. Smith. In this work we have descriptions, with geologic and topographic maps, of portions of Seward Peninsula on the borders of Norton Sound in Western Alaska. A small and useful geologic map of the entire peninsula is also given, and this shows a pre-Ordovician series of gneisses, limestone, and schists, the Kigluaik group; a series of unfossiliferous schists, and of limestones which yield Ordovician and possibly Silurian fossils; and a newer limestone "from which Carboniferous or Upper Devonian fossils have been obtained". There are also andesites of uncertain age, granites of later date, some late

Mesozoic or Tertiary strata, as well as Pliocene and later deposits. Gold has been obtained in profitable quantity from the Hurrah quartz mine, the associated slaty rocks being possibly of Devonian age; but most of the gold is obtained from placer deposits, of which detailed accounts are given. Among the metamorphic rocks there is great complexity of structure, recumbent overturned folds and extensive thrust-faulting being described.

Bulletin 435, 1910, records "A Reconnaissance of parts of North-Western New Mexico and Northern Arizona", by Mr. N. H. Darton. The country here described and shown on a geological map extends along the borders of the railway from Albuquerque on the east to Peach Springs and Kingman on the west. A variety of formations is exposed—Pre-Cambrian, Cambrian, Devonian, Carboniferous, Triassic, Cretaceous, Tertiary, and Quaternary. The region lies mostly in the plateau province, and it includes the Grand Canyon in North Central Arizona, where the ground rises to more than 8,500 feet and the deep gorge is at its base 2,436 feet above sea-level. Some effective views are given of the Canyon, of pre-Cambrian granite with nearly vertical jointing, of the Wingate Sandstone (Triassic), of Bad Lands, a typical desert valley, and of a recent volcanic cone, etc. In the 'petrified forest' of Arizona, which is of Triassic age, the logs occur in a conglomeratic sandstone, the 'Lithodendron formation', but as the beds are eroded the silicified trunks accumulate at the surface at various levels. The principal species, *Araucarioxylon arizonicum*, was described by Mr. F. H. Knowlton. The higher portion of the Trias, known as the 'Painted Desert formation' on account of its banded and brilliantly coloured sandstones, may possibly include beds of Jurassic age.

The principal mineral resources of the area are coal and copper; but asbestos, gold, gypsum, limestone, and building-stone are of importance.

Bulletin 425 deals with the practical question of "The Explosibility of Coal Dust", by Mr. G. S. Rice and others. Bulletin 429 treats of "Oil and Gas in Louisiana, with a brief summary of their occurrence in adjacent States", by Mr. G. D. Harris. The author deals with the occurrence of oil and gas (1) in "Saline Domes", the nuclei of which are generally found to be made up of rock-salt, while oil and gas have been concentrated in enormous quantities, the surrounding territory being barren, and (2) in "Stratum oil and gas fields", where the materials are coextensive with certain widespread geological strata, though occurring in commercial quantities only in areas where the structure is favourable.

A "Preliminary Report upon the Oil and Gas developments in Tennessee" has been prepared by Mr. M. J. Munn for the State Geological Survey of Tennessee (Bulletin 2E, 1911).

VI.—Brief Notices.

1. Iowa.—In an account of "The Pleistocene Deposits in Warren County, Iowa" (Univ. Chicago Press, 1911), Mr. J. L. Tilton discusses the physical changes which the area has undergone in Quaternary times. The pre-Glacial topography was wholly unlike that of the present; it was almost entirely obliterated by the "sub-Aftonian

drift" (Boulder-clay); a new topography was developed when the "Aftonian Interglacial deposits" were accumulated; and the main features then produced are those of the present day. Minor features were affected by a partial mantling of Kansan drift, by later erosion, and also by local deposition of loess.

2. California.—A well-illustrated report on "The Geomorphogeny of the Sierra Nevada north-east of Lake Tahoe" has been prepared by Mr. John A. Reid (Univ. California Public, vol. vi, p. 89, 1911).

3. Geology of the Argentine Republic.—A memoir entitled "La Precordillera de San Juan y Mendoza", by Dr. Richard Stappenbeck, is descriptive of the fourth section of the Geological Map, which embraces a belt of country extending from San Juan northwards to Jachal and southwards to Mendoza, along the western borders of the Republic. The formations represented on the map (scale 1:500,000) include Pre-Cambrian (?), Lower Silurian (or Ordovician), Devonian, Carboniferous, Permian, Trias, Rhætic, Jura–Cretaceous, various Pleistocene and recent deposits, and Igneous rocks. In the memoir the various rocks are described, together with the structure of the country; lists of fossils are given, and the mineral products and underground waters receive due attention. The memoir contains a number of illustrations of the geological features, and is published as volume iv, No. 3 of the Anales de Ministerio de Agricultura (Sección Geología, Mineralogía y Minería), Buenos Aires, 1910.

4. South Australia.—Mr. Walter Howchin has described a "New and Extensive Area of Permo-Carboniferous Glacial Deposits" in the country between Strathalbyn and Port Elliot, south of Adelaide (Trans. Roy. Soc. S. Australia, vol. xxxiv, p. 231, 1910). The subject is well illustrated by a geological map and fourteen plates.

5. Measurements of the Increase of Temperature in Bore-holes (Trans. Inst. Mining Engineers, vol. xxxix, 1910).—In this paper Messrs. J. Königsberger & M. Mühlberg express the view that "Various causes exist (together or separately) for an abnormally elevated temperature in the deeper-lying portions of the earth's crust: the increase of plutonic influences (comparatively recent intrusive bodies); ores in process of oxidation; minerals, such as anhydrite, in course of hydration; sulphur deposits; bituminous minerals, especially petroleum; coals not yet transformed into anthracite; thermal springs"; etc. The authors suggest that an abnormally elevated temperature may be "an indication of the said more or less valuable materials", and that for depths of 600 feet or more, "Temperature-measurements should form part of the routine of boring, whether they prove of immediate practical value or not."

6. Sussex.—In an account of "The Older Prehistoric Races of Sussex" (Eastbourne Nat. Hist. Soc., 1910) Mr. W. J. Lewis Abbott draws attention to the plateau or eolithic implements, "relics of Pliocene man," found in the county; and to a particular discovery of Palæolithic implements north-east of Hastings, many examples being identical with forms found in the French caves of Magdalenian age, and termed by him "Fairlightian". Mr. Abbott expresses his conviction that the implements of Cissbury (long classed as Neolithic) are of Palæolithic age.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I. *March* 22, 1911.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communications were read:—

1. "On some Mammalian Teeth from the Wealden of Hastings." By Arthur Smith Woodward, LL.D., F.R.S., F.L.S., Sec.G.S.

Mr. Charles Dawson, F.S.A., F.G.S., has obtained two imperfect molars, apparently of *Plagiaulax*, from beds of grit in the Wealden near Hastings; and his associates in the work of exploration, Messrs. P. Teilhard de Chardin and Félix Pelletier, have found a well-preserved multituberculate molar of the form named *Dipriodon* by Marsh. These specimens are described.

Mr. Dawson said there were three horizons where bone-beds constantly occur: (1) in the Upper Tunbridge Wells Sands just below the Weald Clay (being the true 'Tilgate Grit' of Mantell); (2) at a great depth below the former, at the base of the Wadhurst Clay, in the blue clay above, and sometimes associated with, the thick bed of calcareous sandstone ('Blue Stone'); and (3) about 26 feet below No. 2 (at Hastings), at the top of the Ashdown Sand; it is less fossiliferous than either of the former, and is usually associated with bands of calcareous sandstone. So far, mammalian remains had not been discovered in No. 1; Nos. 2 and 3 had yielded the teeth ascribed to *Plagiaulax*, and now No. 3 had also furnished *Dipriodon*.

2. "Some Observations on the Eastern Desert of Egypt, with Considerations bearing upon the Origin of the British Trias." By Arthur Wade, B.Sc., F.G.S.

This paper deals chiefly with phenomena observed in the Eastern Desert of Egypt, bordering the Gulf of Suez and that part of the Red Sea which is adjacent to its junction with the Gulf. The mounds of igneous debris which flank the coastal hill-ranges are described, and their origin is discussed and connected with the raised-beach phenomena present in the area. The distances to which fragments of igneous rock derived from these hills have travelled in Egypt are shown.

The shore-sands are next dealt with, and their origin ascribed mainly to the breaking down of local rocks, and not necessarily to the denudation of Nubian Sandstone areas as has been supposed. In the marly beds connected with the recent shore-deposits, tiny dolomite-rhombs, similar to those found by Dr. Cullis in the Keuper Marls, are present. Some effects of wind-blown sand are described, especially the wedging of the sand-grains into cracks produced by other forces of disintegration.

Deposits of rock-salt and gypsum are being laid down at present in the area. The alteration of the calcium carbonate in recent shell-beds to gypsum, with the accompanying destruction of organic remains, is noted; and its significance with regard to the origin of gypsum-beds and the concurrent absence of fossils in some of the older series of strata is pointed out. Analyses of different deposits are given, and the presence of sodium carbonate and epsomite crystals is proved in the encrustations upon recent fossil shells. The characters of the massive older gypsum and rock-salt deposits are described, together with the distribution and lithological changes in the beds when traced across the area by means of borings and outcrops. The origin of the gypsum series is shown to be connected with inland salt-lake conditions, and evidence is presented which suggests that these conditions were contemporaneous with the Oligocene continental period in Egypt, and with the formation of the well-known beds of the Fayûm in the Western Desert. A sketch-map showing, for the first time, the geology of the island situated in the mouth of the Gulf of Suez accompanies the paper.

3. "Faunal Horizons in the Bristol Coal-field." By Herbert Bolton, F.R.S.E., F.G.S., Curator of the Bristol Natural History Museum.

The author has been engaged for three years in the examination of the Coal-measures of the Bristol Coal-field, and has determined the existence of faunal horizons at the collieries of South Liberty, Easton, Hanham, Speedwell Deep, and Coalpit Heath in the Bristol and Gloucestershire area, and at Ludlows, Middle Pit, Tyning, Wellsway, Writhlington, Foxcote, Dunkerton, Newbury, and Mackintosh collieries in the Radstock area. A measured section of 760 feet between the Ashton Great Vein and the Bedminster Great Vein at the South Liberty Colliery, Bristol, has been examined in detail, and four faunal horizons discovered. These horizons occur at 134, 284, 286, and 637 feet respectively below the Bedminster Great Vein. In every case the fauna was marine in character, and the author's work shows that the Ashton and Bedminster Series of Bristol, the Coalpit Heath and Parkfield Series of the northern part of the coal-field, and the Vobster Series of Radstock are all characterized by a fauna agreeing with the typical fauna of the Lower Coal-measures of the coal-fields of the Midlands and of Lancashire and Yorkshire.

Species of *Carbonicola* are rare, while the Cephalopod and fish fauna is poor. The Second or Farrington Series of the Upper Coal-measures has yielded *Lingula mytiloides*, several species of Ostracods, four species of *Anthracomya*, and scales of *Strepsodus sauroides*. *Cœlacanthus elegans* has been found in the First or Upper Radstock Series. The presence of marine phases in the Bristol Coal-field is confirmatory of the evidence obtained by Mr. W. H. Dyson in the Yorkshire Coal-field, where an extensive fauna has been found in four horizons above the Barnsley Coal.

In the Bristol, as in the Yorkshire Coal-field, the marine fauna undergoes no marked change in its upward range, specific identity being retained in the uppermost horizons, while new species are rare.

Insect-wings referred to the genus *Genentomum* have been found at one horizon in the South Liberty Colliery, Bristol, 637 feet below the Bedminster Great Vein; while the rare Phyllopod, *Leaia leidyii*, var. *salteriana*, hitherto only known from the Lower Carboniferous of Fifeshire, was found in great abundance in the roof-shales over the High Vein of the Parkfield Series at Coalpit Heath Colliery. Frequently the specimens occurred in dense clusters, the latter being distributed over the surface of the slabs of shale. The smallest are not more than 2 mm. in length, the largest reaching 8 mm.; hundreds of examples were found. The total number of species now recorded by the author from the Bristol Coal-field amounts to seventy-four; they are as follows: Echinodermata, 1; Vermes, 2; Brachiopoda, 9; Pelecypoda, 25; Gasteropoda, 13; Cephalopoda, 8; Arthropoda, 6; and Pisces, 10.

II. *April* 5, 1911.—Dr. C. W. Andrews, B.A., F.R.S., Vice-President, in the Chair.

The following communications were read:—

1. "Trilobites from the *Paradoxides* Beds of Comley (Shropshire)." By Edgar Sterling Cobbold, F.G.S.; with Notes on some of the Associated Brachiopoda by Charles Alfred Matley, D.Sc., F.G.S.

The author describes and illustrates the type-specimens of *Paradoxides Groomii*, Lapworth, 1891, and the associated Trilobites from the basement beds of the Middle Cambrian of Comley Quarry. Among the latter there are two or three other species of *Paradoxides*, represented by fragments insufficient for specific determination; also a species of *Dorypyge* allied to *D. oriens*, Grönwall, and one of *Conocoryphe* allied to *C. emarginata*, Linnarsson. He also describes some of the Trilobites from a higher horizon containing *Paradoxides Davidis*, Salter, and *P. rugulosus*, Corda; and notes on the Brachiopoda from this horizon are contributed by Dr. Matley.

A complete list of the Trilobites hitherto identified from the local Cambrian deposits is given, arranged under the following provisional faunal groups:—

MIDDLE CAMBRIAN.

Davidis Fauna from the Shoot Rough Road Beds.
Groomii Fauna from the Quarry Ridge Grits.

LOWER CAMBRIAN.

Protolenus–Callavia Fauna from the Grey and *Olenellus* Limestones.

The author draws attention to the great divergence between the two last-named faunas, and also describes the recently exposed evidence of the accompanying physical break between the Middle and the Lower Cambrian beds of the locality: arguing from the analogy afforded by American deposits that, if the *Olenelli* with telson-like pygidia were ever present in Shropshire, their place in the local series would be among the strata cut out by the unconformity.

2. "The Stratigraphy and Tectonics of the Permian of Durham (Northern Area)." By David Woolacott, D.Sc., F.G.S.

The Permian strata of Durham and Northumberland lie unconformably on a basin of the Coal-measures. They can be divided as follows:—

(4) Upper red beds with salt and thin fossiliferous Magnesian Limestones (only exposed in the south of Durham). 300 feet.

(3) The Magnesian Limestone.
 (*a*) Upper.
  1. Yellow bedded limestone of Roker. 100 feet.
  2. The concretionary limestone of Fulwell and Marsden—a series of concretionary and non-concretionary limestones and marls. 150 to 250 feet.
  3. The Flexible Limestone. 10 to 12 feet.

(*b*) Middle.

(1) Unbedded (as a rule), highly fossiliferous (often) limestone of Claxheugh, Tunstall, etc. Forms a ridge of high ground and reaches a thickness of 300 feet. Often brecciated and entirely changed in character —rendered more calcareous and fossils obliterated.	replaced on the east by	Bedded yellow, non-fossiliferous limestones of the northern end of Marsden Bay and the coast from Hendon to Seaham Harbour. Often highly brecciated. 150 feet.

(*c*) Lower. Bedded brown limestones of Frenchman's Bay, Houghton, etc. Upper beds often disturbed. 40 to 200 feet.

(2) The Marl Slate. 3 feet.

(1) The Yellow Sands, from 0 to 150 feet.

These beds, which vary much in thickness, lie in North Durham in the general form of a syncline beneath Sunderland.

The unfossiliferous Yellow Sands are probably a deltaic formation reassorted by wind, the other beds being the result of deposition in an inland sea undergoing desiccation. The magnesium carbonate existed in the waters of the sea, and was either deposited along with the calcium carbonate, or introduced by seepage when the beds were being laid down.

Great changes in the amount and distribution of these carbonates has, however, taken place since deposition. The cellular structures that occur in the limestone can be classified as follows: (1) concretionary-cellular; (2) negative breccia; (3) solution-cavities; and (4) fractured cellular. Most of them have been produced by the leaching-out of the magnesium carbonate (dedolomitization), or of both that and calcium carbonate. In some cases the rock has been rendered crystalline, as well as more calcareous, and the fossils have been obliterated. They do not afford any proof that the rock has been dolomitized subsequent to deposition. The percentage of calcium carbonate is sometimes over 99, while that of magnesium carbonate is occasionally as much as 50.

The fauna of the Magnesian Limestone is very restricted (about 140 species) and most peculiarly distributed. The marked palæontological features are the profusion of individuals in the Middle Fossiliferous Limestone (which appears to have formed a shell-bank in the Middle Magnesian Limestone sea), and their sudden disappearance in the Upper Limestone. No Corals, Echinoderms, Polyzoa, Brachiopods, or Cephalopods have ever been found above the top of the Middle Fossiliferous division, only a few fishes, Gasteropods, Lamellibranchs, Entomostraca, and Foraminifera occurring in the Upper beds. The Lower and Middle Fossiliferous Limestones are marked by the presence of *Productus horridus*, Sow. Fish-remains occur at two horizons: namely, the Marl Slate and the Flexible Limestone, and the beds above these deposits.

The Brecciated Beds, which occur at various horizons, chiefly, however, in the two Middle divisions, constitute the most marked tectonic feature of the Magnesian Limestone of the area. They have been produced by thrusting, which brought about a decrease in the lateral extension of the Permian. Associated with the breccias are other proofs of thrusting: (1) thrust or shear-planes; (2) disturbed and displaced masses of Lower Limestone; (3) intruded breccias; (4) slickensided and grooved, horizontal and vertical surfaces; (5) cleavage; (6) folding, both on a local and on a general scale; (7) buckling, thickening, and squeezing-out of beds; (8) phacoidal and other structures; and (9) fissuring. The main thrust at Marsden appears to have acted from a few degrees south of east to a few degrees north of west; there are, however, distinct evidences of movement from other directions in different parts of the district. Experiments made on the compressive strength of the rocks affected by the thrust at Marsden indicate that the thrusting reached a maximum of about 300 tons per square foot. Observations made by Mr. S. R. Haselhurst, M.Sc., in the Cullercoats area seem to prove that the thrusting occurred later than the post-Permian movement of the Ninety Fathom Dyke—some faulting in the area is, however, later than the thrusting—and it appears evident that the shattering of the strata was produced prior to the Pre-Glacial era of denudation. It may have been connected with the Miocene movements that produced such marked changes in the physiography of Britain.

CORRESPONDENCE.

THE LIMESTONE FRAGMENTS IN THE AGGLOMERATE OF THE "ROCK AND SPINDLE" VOLCANIC VENT, ST. ANDREWS, FIFE.

Sir,—Since the publication of my note under the above-named title (see Geol. Mag., May, p. 201) I have to record the further observation of a very remarkable fact. During a recent visit to the "Rock and Spindle" my friend Mr. R. M. Craig, M.A., B.Sc., of the Geological Department, St. Andrews University, and myself found that certain large masses of rock which stand almost vertically in the seaward extension of the agglomerate, and which we had long been accustomed to regard as consisting merely of hardened sandstone—they weather curiously like some of the siliceous sandstones along the shore—were in reality portions of a seam of limestone which must have measured at least 12 feet in thickness. These contain very large crinoid stems, isolated cup corals, polyzoa, etc., and look exactly as if they belonged to some of the beds at the base of the Carboniferous Limestones as exposed on the coast at Pittenweem. Certainly they can scarcely have come from the Calciferous Sandstones, and would accordingly appear to afford the strongest confirmation of the above opinion based almost solely on the palæontology of the fragments at the upper part of the beach.

David Balsillie.

DREIKANTER.

Sir,—The reviewer to whom Mr. Grabham objects (Geol. Mag., May, 1911, p. 239) seems in his review (Geol. Mag., Feb., p. 85) to describe the words 'dreikanter', 'zeugen', etc., as 'technical terms'.

They are certainly not more technical, and I should have thought even less technical, than the phrases 'facetted pebbles' and 'tabular outliers' which he prefers. They don't mean the same thing, it is true; but supposing they did, the objection to them seems to me that they are German and not English. In so far, I agree with your reviewer rather than with Mr. Grabham. One should distinguish very carefully between the using of foreign words out of laziness or because one is ignorant of one's own language, and the use of a correct technical term. A technical term, to be worthy of the name, should be clearly defined, and should be capable of use in all languages with equal convenience. For this reason it is generally preferable to form technical terms out of Greek or Latin words.

The word 'Dreikante' is not a good technical term. It does not mean a wind-worn pebble, but a tripyramidal or triquetral pebble, and the wind-worn pebbles that have this shape are in a minority. In the second place, being German and not English, it presents peculiar difficulties. Mr. Grabham himself writes of 'a dreikanter', when he means a Dreikante (though it is not clear that he would exclude Einkanter, Zweikanter, Vierkanter, u.s.w.), while the last gentleman who wrote on them in your pages persistently spoke of 'Dreikante' when he meant 'Dreikanter'. German is an excellent language—for Germans; but when I am writing for Englishmen, I prefer to write in English, rather than to risk errors in a foreign tongue.

F. A. Bather.

May 2, 1911.

THE LAND-ICE QUESTION.

Sir,—Though I ought to leave Mr. Deeley to reply for himself, is not the difficulty raised by the Rev. O. Fisher in the Magazine for May, p. 238, removed when we regard the so-called ground-moraine of Boulder-clay as consisting originally of intraglacial material, moved forward at various levels within and with the body of the ice? This is the view forced upon one by the examination of Arctic glaciers, as Garwood and Gregory and others have pointed out. Even in India, as T. D. La Touche shows, some glaciers consist largely of stones. A composite mass of this kind may do a large amount of damage to its floor. The conception of the formation of Boulder-clay as an independent entity under ice is probably not commonly held at the present time by glacialists.

Grenville A. J. Cole.

Geological Survey of Ireland, Dublin.
May 10, 1911.

OBITUARY.

ÉDOUARD FRANÇOIS DUPONT.

Born January 31, 1841. Died March 31, 1911.

We regret to record the death at Cannes, at the age of 70, of É. Dupont, the Honorary Director of the Royal Museum of Natural History at Brussels. The results of his early geological studies on the Carboniferous Limestone of Belgium and on the fossil Cephalopods date from 1859, and he subsequently published observations on the Devonian.

On that subject his most important paper was entitled "Terrain dévonien de l'Entre-Sambre-et-Meuse: Les îles coralliennes de Roly et de Philippeville" (Bull. Mus. R. Hist. Nat. Belg., 1882). Dupont is perhaps best known for his long-continued researches on the Belgian caverns, especially those on the borders of the Meuse and of its tributary the Lesse, some account of which was given in the Geological Magazine for 1866, p. 566. To the Quaternary deposits of the valleys, the fossil mammals, and the question of the Antiquity of Man he devoted much attention, and the results of much of this work was embodied in a volume entitled *L'homme pendant les Ages de la Pierre dans les Environs de Dinant-sur-Meuse*, 1871 (2nd ed. 1872). In 1865 Dupont had published an essay on a geological map which he had prepared of the country around Dinant, his birthplace. In later years he was associated with M. Mourlon, now Director of the Geological Survey of Belgium, in the preparation of a general map of the country, and in many of the separate sheets (on a larger scale) issued by the survey. In his *Géologie de la Belgique* (1880) M. Mourlon has given a list of Dupont's publications up to that date. In 1887 he turned his attention to the Congo, and after personal explorations in that territory he published observations on the geology, anthropology, and other natural history subjects, in *Lettres sur le Congo. Récit d'un voyage scientifique entre l'embouchure du fleuve et le confluent du Kassaï*, 1889.

As Director of the Royal Museum Dupont was much interested in the remains of *Iguanodon*, almost complete skeletons of which were obtained from the Wealden of Bernissart, near Mons, and mounted under his superintendence. A reproduction of the *Iguanodon Bernissartensis*, Boulenger, was set up in the Geological Department of the British Museum (Natural History) and figured with descriptive remarks by Dr. H. Woodward in the Geological Magazine for July, 1895, p. 289.

Among the later publications of Dupont was an account of "Bernissart et les Iguanodons" in a Guide to the Collections in the Brussels Museum, 1897.

Dupont was elected a Foreign Correspondent of the Geological Society of London in 1879, and a Foreign Member in 1897.

H. B. W.

ALEXANDER SOMERVAIL.

Born March 4, 1841. Died December 30, 1910.

The close of the year 1910 witnessed the death of Alexander Somervail, a worthy successor in his scientific pursuits to William Pengelly, F.R.S., whose post, as Hon. Secretary of the Torquay Natural History Society, he was chosen to fill when its noted founder, the explorer and historian of Kent's Cavern, retired after forty-five years unremitting work. The traditions, activities, and success of the Society were ably maintained by the succeeding secretary for nearly twenty years, when he, too, aged in its service, reluctantly resigned only a few months before his decease in Torquay on December 30, 1910, in his 70th year.

Alexander Somervail was born in 1841 in the Water of Leith district of Edinburgh, and lived the larger half of his life within and near that centre of intellectual activity. His self-contained and contemplative temperament was early displayed in his solitary habits, and the interest he took in collecting 'curios' and an earnest regard for the study of nature which increased with growing years. To follow this inclination became his chief relaxation and recreation during the time he could spare from the business occupation which formed his necessary means of livelihood. With the care, attention, and judgment which ensure success he found himself, at length, the proprietor of a prosperous business in Edinburgh.

During these years he had associated himself with the learned Societies of the city, and became a member of the Philosophic Institution, the Naturalists Field Club, and the Geological Society of Edinburgh. He was thus brought into contact with many of the leading men of science in the city, and with such help and stimulus he soon became a keen student and active member. Turning his attention chiefly to geology he devoted all his spare time to traversing and examining the country around Edinburgh so as to gain practical knowledge of the district geologically.

Finding the severe winters of Edinburgh affecting his health he determined to leave his native place for a milder climate. Consequently in 1880 he started a business in Falmouth. There he met Mr. Howard Fox, F.G.S., whom he also inspired with an enthusiasm for geological research, by which a warm friendship was established, resulting in many visits to the strange complex of rocks of the Lizard district, and other geological excursions, even as far afield as the Western Isles of Scotland. Some of the results of these investigations were placed before the Royal Geological Society of Cornwall, for which that body later on elected him an honorary member. For his paper on "The Geology and Scenery of Falmouth and District", read before the Royal Polytechnic Society of Cornwall, he was awarded the bronze medal of that Society.

After two years residence in Falmouth he removed to Torquay, attracted by the Natural History Society and Museum, of which he at once sought membership and was elected in October, 1883, reading his first paper to the Society a month later.

He started a business in Torquay, but soon disposed of it and devoted his whole time and attention to geology and to the work of the Natural History Society. In 1890 he was called upon to take in hand the Honorary Secretaryship of the Society, a work for which he was well fitted. The Society passed through some critical phases during his secretaryship, but the lectures and monthly papers never failed, and his genial presence, courteous interest, and ready help drew many members. His never-flagging enthusiasm for nature study was contagious, and he inspired many to follow Natural History pursuits in the field. He attended the meetings of the British Association, of which, as well as of the Devonshire Association, he was a member, and contributed papers on geology to both.

Having satisfied his desire by a personal visit to the most interesting geological areas in Britain, he sought wider fields for geological observation abroad. Alone and with command of no other than his native language he rambled the Eifel district, the Auvergne, parts of Norway, and Southern Italy. In the same way he visited Egypt, going up the Nile to the First Cataract, Jerusalem, Damascus, Athens, Constantinople, Vienna, Berlin, and Amsterdam. He also paid a visit to Switzerland and accompanied the British Association in its meeting to South Africa.

His contributions to the literature of geology are contained mostly in the Transactions of the Royal Geological Society of Cornwall and of the Devonshire Association, in the Geological Magazine, and the Journal of the Torquay Natural History Society, the present number of which contains a list of twenty-four of his geological papers. Unfriendly criticism attended the publication of some of his views, but he never alluded to the matter nor appeared to resent the harshness of the treatment.

His interest in geological matters continued unabated. Apparently little concerned by his critics he pursued his favourite study satisfied with the new facts and interest it unfailingly gave him. The value of his services to the Torquay Natural History Society will be long appreciated, and his memory will be kept green by a legacy left by him to its funds, which betokens the interest and pleasure he experienced in the performance of his duties to that institution.

H. J. L.

PROFESSOR M. H. NEVIL STORY MASKELYNE, M.A., Hon. D. Sc. Oxon., F.R.S., F.G.S.

Born 1823. Died May 20, 1911.

With deep regret we have to announce the loss of the well-known mineralogist Professor Story Maskelyne, at his residence, Basset-Down House, Swindon, Wilts, at the age of 87. His grandfather, Nevil Maskelyne, was Astronomer Royal for forty-seven years; his father was a Fellow of the Royal Society and a double-first at Oxford when he was 19. Mr. Maskelyne followed his father, and graduated from Wadham College, Oxford, of which, afterwards, he became an honorary Fellow. He was Professor of Mineralogy in Oxford 1856–95.

But his most distinguished services to Mineralogy are those associated with his appointment of Keeper of Minerals in the British Museum in 1857, a post which he held for twenty-three years, until he entered Parliament in 1880. The collection he found was but a small one, but by timely purchases he was enabled to make it probably the best in the world. He practically created the collection of Meteorites, now one of the finest in existence. His researches in the structure and composition of Meteorites were amongst the most important of his time, and led to the discovery in 1862 of a new mineral in the Bustee Meteorite, which he named 'Oldhamite', and in 1863 he detected enstatite as a meteoric ingredient. Another new mineral named 'Asmanite' was added in 1869. Commencing in 1858 with only Mr. Thomas Davies to assist him, he acquired (1) the eminent services of Dr. Viktor von Lang; (2) W. J. Lewis, F.R.S., now Professor of Mineralogy in Cambridge; (3) Dr. Walter Flight, a very able chemist; and (4) Mr. Lazarus Fletcher, M.A., F.R.S. (afterwards his successor as Keeper of Minerals and now Director of the Natural History Museum).

Mr. Maskelyne was elected a F.R.S. in 1870, and was awarded the 'Wollaston Medal' by the Council of the Geological Society in 1893, in recognition of his great services to Mineralogy. He represented Cricklade in Parliament 1880–5, and North Wilts. 1885–92.—*Morning Post*, May 22, 1911.

MISCELLANEOUS.

Geological Survey of Great Britain.—Dr. John Horne, F.R.S., who joined the staff of the Geological Survey in Scotland in 1867, retires from the public service on June 30. As notified in the Geological Magazine for April, 1901, Dr. Horne was appointed in that year Assistant Director for Scotland, under Dr. Teall as Director. Dr. Horne's service, which has extended over nearly forty-four years, has ever been characterized by enthusiastic and strenuous labour whether in the field or in the office, and by much brilliant research in all parts of Scotland, notably in the North-West Highlands.

We learn (from *Nature*, April 13) that Dr. J. S. Flett has been appointed to succeed Dr. Horne as assistant in Scotland to the Director of the Geological Survey. Dr. Flett is a graduate of Edinburgh University, where he was Baxter Scholar, Falconer Fellow in Geology, and a Heriot Research Fellow. He was for four years lecturer on petrology in the University, and in 1901 joined the Geological Survey. In 1903 he was appointed petrographer to the Survey. After the West Indian eruptions in 1901 he was sent out with Dr. Tempest Anderson by the Royal Society of London to report on the volcanic phenomena. He has published many scientific papers dealing principally with the volcanic and metamorphic rocks of the British Isles, and he has contributed largely to the memoirs of the Geological Survey, not only on Scotland, but also on Cornwall and Devon. For scientific research he was awarded the Neill Medal by the Royal Society of Edinburgh (1902) and the Bigsby Medal by the Geological Society of London (1909).

The First Universal Races Congress is to meet at the University of London, July 26–9, under the presidency of the Right Hon. Lord Weardale, and with the Right Hon. Lord Avebury as one of the Vice-Presidents. The Congress aims to be an assemblage of members of all the races of the world. Professor A. C. Haddon will give a "Demonstration of Racial Types", and he is Director of the Exhibition that will be organized in connexion with the Congress.

The Tenth International Geographical Congress will be held in Rome in the week beginning October 15, under the presidency of the Marquis Raffaele Cappelli. It is interesting to note that the Congress will be divided into the following sections: (1) Mathematical Geography, (2) Physical Geography, (3) Biogeography, (4) Anthropogeography and Ethnography, (5) Economic Geography, (6) Chorography, (7) Historical Geography and History of Geography, (8) Methodology and Didactics.

International Volcanological Institute at Naples.—Although for some time past an observatory has existed on Vesuvius, the means at command have always been insufficient to carry on the systematic investigations that are needed. At the recent International Geological Congress in Stockholm, the founding of the above-named Institute was proposed by Monsignore Immanuel Friedlaender, and approved by the Congress.

The scope of the International Volcanological Institute is to render possible for the first time a continuous and systematic investigation of volcanic phenomena. For this purpose the necessary laboratories and instruments are to be provided, and measurements of temperatures to be regularly made on Vesuvius at different places. The gases are to be periodically collected and analysed, for which purpose a self-contained gas-analytical laboratory will be required; and local earthquakes of volcanic character are to be continuously registered not only during the eruptive phases of the volcano but also throughout its periods of comparative repose.

The volcanic outbreaks of the last decades, the eruption of Krakatoa, of Pelée, of Vesuvius in 1906, and others, have occasioned large economic losses apart from the sacrifice of many human lives. Our present knowledge of volcanic action depends on individual observations and by no means suffices for the foretelling of coming occurrences; nevertheless the fact can be already recognized that in most volcanoes there occurs a regular sequence of events, and it is within the bounds of possibility, and even of probability, that a careful and exact registration of all the phenomena of a given volcano will enable us to foresee approximately the time and magnitude of an eruption.

The practical importance of this is obvious, but the economic results of this form of investigation would also be manifested in another direction. When we can observe more closely the fumarolic activity and the transformation of the rocks we shall be able to form a clearer conception of the origin of ore beds. There are several volcanoes which within their fumarolic districts disclose the presence of small ore bodies which are still in the act of formation. These conditions have not been investigated closely.

The legal form of the International Volcanological Institute will be, at first, that of a Society in which only those members who have subscribed more than 10,000 lire to the capital, or more than 1,000 lire yearly, shall be entitled to voting privileges. Members contributing smaller sums, down to the minimum of 25 lire annually, will be entitled only to the printed matter and publications of the Institute.

The project is supported by Dr. Tempest Anderson, Professor S. Arrhenius, Professor A. Baltzer, Professor H. L. Bowman, Professor G. de Lorenzo, Professor F. Frech, Sir A. Geikie, Professor A. Heim, Professor W. H. Hobbs, Dr. H. J. Johnston-Lavis, Professor F. Lœwinson-Lessing, Professor G. Stefanescu, Professor E. Suess, and many others.

A FUND has been opened for the purpose of presenting a testimonial to Mr. Henry Keeping, who has been for fifty years curator of the Geological Museum, Cambridge, and is now retiring from active work. There are probably many who will welcome this opportunity for expressing their appreciation of Mr. Keeping's long service in the cause of geology. Subscriptions should be sent to Mr. F. R. Cowper Reed, Sedgwick Museum, Cambridge.—*Nature*, April 27, 1911.

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ASSISTED BY

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DR. GEORGE J. HINDE, F.R.S., F.G.S.
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JULY, 1911.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VIII.

No. VII.—JULY, 1911.

ORIGINAL ARTICLES.

I.—The Fundamental Problems of Petrogenesis, or the Origin of the Igneous Rocks.

By Dr. Franz Lœwinson-Lessing, Professor of Mineralogy and Geology, Polytechnic Institute, Sosnovka, St. Petersburg, Russia; For. Corr. Geol. Soc. London.

(*Concluded from the June Number, p.* 257.)

§ 2. *On the Causes of the Diversity of Igneous Rocks.*

THE second fundamental problem of petrogenesis is the following question:—By what processes have there been derived, from the original magma or magmas, all other magmas known as igneous rocks? It is now almost universally admitted that many igneous rocks are genetically connected and produced from an original magma by differentiation, and that in many cases differentiation may be considered as liquation or separating into secondary magmas. But is differentiation (*Spaltungen*) alone sufficient to explain the formation of all igneous rocks? And by what is a magma stimulated to differentiation? These are two questions which must be elucidated. It must be first of all emphasized that not every magma is subject to differentiation. My standpoint is that the principal factors producing and regulating differentiation are on one side the process of crystallization (differentiation by crystallization, *Krystallizations-differenzierung*), and on the other the chemical composition of the magma and its tendency to the formation of eutectics (magmatic differentiation).

Gravitation is the principal factor during differentiation by crystallization: crystals are distributed according to their specific gravity, the one rising to upper portions of the magma, the other sinking into deeper and being often dissolved and assimilated there. Corrosion-rims on phenocrysts and orbicular concretions in plutonic rocks, well known to every petrographer, are suggestive illustrations of the fact that there exist in the magma vertical movements of the first products of crystallization. By this process leucocratic and melanocratic modifications may be generated, and there can issue from one original magma several different rocks genetically and chemically connected with it. Such a process can take place in a separate isolated magma-basin cooling very slowly.

The tendency to form eutectic mixtures is certainly a powerful factor in differentiation, which, as I have already pointed out,[1] is from

[1] F. Lœwinson-Lessing, "Petrographical Notices. 4. Differentiation, Eutectics, and Entropy": Ann. Inst. Polyt. St. Pétersbourg, vi, p. 279, 1906.

the standpoint of entropy not only a possible but a necessary regulator of differentiation. Of course differentiation postulated by the tendency towards eutectics can take place only in a magma which is not itself an eutectic mixture but more or less different from it. If granite and gabbro are really eutexia their magmas must consolidate as a whole, they cannot undergo differentiation without an external impulse, and such an influence is given, as will be shown later, by the admixture and assimilation of foreign mineral masses. And wherever a magma exists the composition of which is not eutectic it must undergo differentiation, if only the cooling and solidification process be not too rapid. In the case of a bimineralic magma there will be generated a monomineralic and a eutectic magma; if the original magma be trimineralic, there will issue a trimineralic eutexia, bimineralic and monomineralic rocks. Differentiation in a eutectic magma is possible only if its composition is modified by the assimilation of foreign masses. The question whether a magma can dissolve and assimilate small portions or considerable quantities of the surrounding rocks has been answered by different geologists in different ways, some denying this possibility, others admitting such a process. During recent years the number of those who admit assimilation has notably increased. It is perhaps sufficient to cite only a few names, as it seems to me that the widespread occurrence of xenoliths and the marginal facies of the intrusive bodies in the contact zones are eloquent illustrations of assimilation on a large scale. And is not assimilation a phenomenon, that must be expected even *a priori* in intrusive bodies, for it is difficult to imagine a magmatic basin heating the rocky masses in contact with it for a long period without partly dissolving them?

Harker[1] considers 'marscoite' to be a case of assimilation of granite by a gabbro-magma. Assimilation on a large scale is admitted by Daly, who has applied this conception to explain the formation of andesites from basalts,[2] and to certain granites.[3] And, in a newly published paper, he tries to demonstrate that all the nepheline-syenites and alkaline rocks connected with them are derivates from granites owing their distinctive characters to the assimilation of limestones.[4] Becke[5] has attributed the richness in lime and magnesia of the Pacific type of lavas to the fact that there have been assimilated great quantities of sediments, and Suess[6] agrees with this supposition. According to

[1] A. Harker, "The Tertiary Igneous Rocks of Skye": Mem. Geol. Surv., 1904. *Natural History of Igneous Rocks*, p. 356. It must be remembered of course that Harker considers such cases as exceptional, and is an adversary of assimilation on a large scale.

[2] R. Daly, "The Origin of Augite Andesite and of related Ultra-basic Rocks": Jour. Geol., 1908, p. 401.

[3] R. Daly, "Secondary Origin of certain Granites": Amer. Jour. Sci., xx (4), p. 185, 1905.

[4] R. Daly, См. прим. на Стр., 123.

[5] F. Becke, "Die Eruptivgesteine des böhmischen Mittelgebirges u. d. Amerik. Anden. Atlantische a. pazifische Sippe der Eruptivgesteine": T.M.P.M., xxii, p. 209, 1903.

[6] E. Suess, *Das Antlitz der Erde*, iii, ii, 679, 1909.

Klemm [1] the diorite of the Odenwald originated through gabbro assimilating schists. Adams [2] speaks of limestones assimilated in the contact zone by granites, and thinks that amphibolites have been formed by this process. Michel-Levy, and with him Haug,[3] considers the formation of granite as being accompanied by endogene metamorphism and assimilation on a large scale. I can cite also Philipp,[4] Termier,[5] Munteanu-Murgoci,[6] Cohen (on the laccolites of Piatigorsk), Mackie,[7] Sauer,[8] Michel-Lévy,[9] Lacroix,[10] Lemberg,[11] Doelter,[12] Gürich,[13] Högbom,[14] Hugi,[15] Sollas,[16] Grenville Cole,[17] the 'osmatic' theory of Johnston-Lavis, and many other authors cited in my "Studien über die Eruptivgesteine". It is well known that Sederholm [18] considers assimilation as an important factor in the formation of the crystalline schists.

The above citations do not give a full account of all the advocates of assimilation, but they are sufficient to show that many authors have been led to this conception by various data and considerations.

In different cases where a magma has come in contact with surrounding rocks or with another magma assimilation must be an important factor in differentiation. It is difficult to imagine a deep-seated magmatic basin to remain in contact with eruptive or sedimentary masses and not to dissolve a part of them, as fused silicates dissolve a porcelain crucible. Those who deny this process on account of the absence of zones of corrosion or of marginal zones due to admixture,

[1] G. Klemm, "Beobachtungen über die genetischen Beziehungen der Odenwälder Gabbros und Diorite": Notizbl. Ver. Erdkunde Grosh. geol. Landesanstalt Darmstadt (4), xxvii, 1906.

[2] F. Adams, "On the Origin of the Amphibolites of the Laurentian Area of Canada": Jour. Geol., xvii, p. 7, 1909.

[3] E. Haug, *Traité de Géologie.*

[4] H. Philipp, "Vorläufige Mittheilungen über Resorptions- und Injectionserscheinungen im südl. Schwarzwald": Centrbl. Min., 1907, p. 76.

[5] E. Termier, "Sur le granite alcalin du Filfla (Algérie)": C.R., 1902.

[6] Munteanu-Murgoci, *Ueber die Einschlüsse von Granat-Vesuvianfels in dem Serpentin des Paringu-Massivs*, 1901.

[7] Mackie, "On Differences in Chemical Composition between the Central and the Marginal Zones of Granite Veins, with further evidence of exchanges between such veins and contact rocks": Trans. Edinb. Geol. Soc., viii, p. 98, 1901.

[8] A. Sauer, "Ueber petrographische Studien an den Lavabomben aus dem Ries": Jahresh. Ver. vaterl. Nat. Württemb., lvii, 1901.

[9] A. Michel-Lévy, *Mémoire sur le porphyre bleu de l'Esterel*, 1897.

[10] A. Lacroix, *Guide des excursions, Congrès de Paris*, 1900.

[11] J. Lemberg, *Z. d. g. G.*, 1872.

[12] C. Doelter, "Chemische Zusammensetzung u. Genesis der Monzoni-Gesteine": T.M.P.M., 1902, p. 206.

[13] Gürich, "Granit u. Gneiss": Himmel u. Erde, xvii, p. 6, 1905.

[14] A. Högbom, "Pre-Cambrian Geology of Sweden": Bull. Geol. Inst. Upsala, x, 1910.

[15] Hugi, "Vorläufige Mitteilung über Untersuchungen in der nördlichen Gneiszone des zentralen Aarmassivs": Eclogæ Geol. Helvet., ix, No. 4, 1907.

[16] Sollas, Trans. Roy. Ir. Acad., xxx, p. 505, 1894.

[17] Grenville Cole, Sci. Trans. Roy. Dublin Soc. (2), vi, p. 246, 1897. The last two authors are cited after Harker, *Natural History of Igneous Rocks*, p. 338.

[18] J. Sederholm, "Om Granit och Gneiss": Bull. Com. Géol. Finlande, No. 3, 1907.

seem not to admit that foreign mineral masses must be 'assimilated' in the real sense of the word, commingled with the whole magmatic mass on account of the fluidity of the magma and the gases it contains. In an intrusive body of laccolitic type assimilation takes place in the manner of stoping as elucidated by Daly. A third case of assimilation, when parts of the solid crust are melted by rising of the isogeotherms or by hot gases, will be mentioned later.

Let us now consider what happens when assimilation has taken place. The magma becomes more fluid, its composition is modified; if it was at first eutectic it is now no longer so, and differentiation must begin. It has been stated by Brögger[1] and myself[2] that differentiation consists in the separation (*Abspaltung*) of definite compounds of minerals, and not of separate oxides, as has been formerly presumed by Iddings and others. We have no examples of magmas having an abnormal composition; even the effusive rocks, which are not entirely composed of crystallized minerals like the intrusives and whose glassy parts may have, as it seems, an arbitrary composition, repeat in reality only the same types of magma which are represented by intrusive rocks. This is a very important fact, demonstrating, as I have already explained,[3] "that the effusive and intrusive rocks come from one source; the differentiation of their original magmas is performed in the same way, namely, in the liquid state." It is also important in showing that the abyssal magmas have time enough and sufficient liquidity for differentiation to continue until it is completed, and in such a manner that no abnormal residual magmas can be formed. We may therefore conclude that every time an abyssal magma has dissolved and assimilated mineral masses, modifying its composition in such a way that the magma has become abnormal, differentiation takes place and the original magma is divided into secondary magmas. On the basis of considerations given in a former paper[4] we may assume that this process of differentiation is governed by the tendency of the magma to separate into magmas having the composition of eutectics and into monomineralic magmas; sometimes the eutectic composition is realized directly, sometimes the original magma is divided into two magmas both of which undergo further differentiation. I propose to give on a subsequent occasion some illustrations of this process; two examples, however, may be cited now—the formation of nepheline-syenites from granites through the assimilation of limestones, according to Daly, and the formation of syenitic rocks from a gabbro-noritic magma by the assimilation of alkali-bearing rock-masses.

[1] W. Brögger, *Die Eruptivgesteine des Kristianiagebiets.* III. Das Ganggefolge des Laurdalits. 1898.

[2] F. Lœwinson-Lessing, "Etudes de pétrographie générale, avec un mémoire sur les roches éruptives d'une partie du Caucase Central," p. 178: Trans. Soc. Nat. St. Pétersbourg, 1898. "Studien über die Eruptivgesteine," p. 187: Compt. rend. VII Congr. Géol., 1899. See also the Proceedings of the Congress of St. Petersburg, p. clviii.

[3] F. Lœwinson-Lessing, "Petrographical Notices. 3. Is there a difference in the chemical composition of the intrusive and the effusive rocks?": Ann. Inst. Polyt. St. Pétersb., vi, p. 274, 1906.

[4] "Differentiation, Eutectics, and Entropy": loc. cit.

The hypothesis formulated above is the further development of the syntectic-liquational hypothesis (assimilation-differentiation theory), announced by me in 1898. Daly[1] has accepted this hypothesis and made use of it in his paper on the origin of the alkaline rocks. I highly appreciate Daly's endeavour to apply my hypothesis to concrete cases, and I am a supporter of several of his own views. But it is necessary to mention that Daly is wrong in thinking that he enlarges my hypothesis. He cites me as follows: ". . . bisweilen genügt ein Einschmelzen einer unbedeutenden Menge irgend eines fremden Stoffes, der im Magma oder in einem Theil desselben wenig löslieb ist, um einen Anstoss zur Spaltung in mehr oder weniger grossem Maastabe zu geben,"[2] and concludes from this passage that I mean only such assimilated masses as are with difficulty, or not at all, soluble in the magma. But from other passages it can be easily seen that I have given to this hypothesis a wider sense, and that there is no 'enlargement' of it in Daly's statements. This may be seen in the whole chapter from which the above passage is cited, and especially from the following passages:—"Dort, wo das Einschmelzen in kleinem Maasstabe stattfindet, zeigt sieh die Resorption in der Zusammensetzung des Gesteins durch das Auftreten neuer Minerale oder durch eine Veränderung der relativen Mengen der das Gestein zusammensetzenden Minerale. Dort, hingegen, wo das Einschmelzen von bedeutenden Mengen fremder Gesteinsmassen stattfindet, führt dasselbe ohne Zweifel zu einem Zerfall zur Differentiation des Magmas bei seinem Erkalten,"[3] and "dass eine Uebersättigung des Magmas mit einer Gruppe von Basen sich oft nicht durch ein Einfaches Ausscheiden des Ueberschusses ausgleicht, sondern in vielen Fällen eine Spaltung auf irgend welche Weise hervorbringen muss".[4]

And so the question standing at the head of this chapter may be answered as follows:—

1. Differentiation by crystallization is regulated by the density of the minerals in process of formation. The deeper parts of the magmatic basin, where the sunken minerals are dissolved, obtain in this way a somewhat different composition, as has been already expressed by myself[5] and developed by Schweig.[6]

2. The magmatic differentiation taking place in the liquid state is induced by assimilation and governed by the tendency towards the formation of definite magmas which can consolidate as rocks, especially eutectic and monomineralic ones.

3. In the intermediate zones between magmatic masses formed by the processes 1 or 2 a mingling of the two may take place, and

[1] R. Daly, "Origin of the Alkaline Rocks": Bull. Geol. Soc. Amer., xxi, p. 117, 1910.

[2] F. Lœwinson-Lessing, *Studien über die Eruptivgesteine*, p. 188.

[3] Ibid., p. 183.

[4] F. Lœwinson-Lessing, "Kritische Beiträge zur Systematik der Eruptivgesteine: I. Zur Chemie der Magmen": T.M.P.M., xix, p. 299, 1900.

[5] "Studien über die Eruptivgesteine."

[6] M. Schweig, "Untersuchungen über die Differentiation der Magmen": N.J., Beil. Bd., xvii, p. 516, 1903.

from these mixtures there have originated those accidental rocks which can be designated, after Harker, as hybrid rocks.

§ 3. *On the Origin of the Igneous Rocks.*

Let us now consider the third fundamental problem of petrogenesis. What origin have the igneous rocks, and why are they represented by the same types in all periods?

Different geological data and theoretical considerations lead to the conclusion that the identity of the eruptive rocks of all geological periods can be most satisfactorily explained by the assumption that from the Archæan up to the present the eruptive rocks represent nearly the same material, which has been subjected several times to weathering, metamorphism, refusion, and regeneration. The assumption that we find or can find anywhere the primordial solid crust of the globe must be definitely abandoned. The occurrence of clastic and sedimentary rocks in the oldest Archæan formations and numerous examples of refused and recrystallized rocks in these formations eloquently sustain and complete the theoretical considerations which lead us to the conception that the primordial crust has been re-melted long ago, and probably more than once. Such a fusion of parts of the solid crust is sometimes directly attributable to a rising of the isogeotherms at the places in question. In reality the process may be a more complicated one, as can be shown by the following considerations. A series of sedimentary rocks 30,000 feet thick (the greatest thickness we can admit) would simply by the rising of the isogeotherms acquire in the lowest beds a temperature of 300°, which is quite insufficient for melting these materials. But the geosyncline, where sedimentation of our 30,000 feet of sediments has taken place, may itself consist of an older series of sedimentary material. At a depth of 60,000 feet under the bottom of our geosynclinal the temperature would be 600° C. before sedimentation, and would rise to 900° C. after the deposition of 30,000 feet of sediments. Under the weight of this new sedimentary sheet of 30,000 feet the area in question would probably bend and subside; this would give for a presumable subsidence of 10,000 feet a further increase of 100°, and so the primary temperature would in this way rise from 600° to 1,000° C. All these figures are, of course, hypothetical. But we must bear in mind that epeirogenetic and orogenetic movements can occasion a far greater subsidence of parts of the crust than the process of sedimentation by itself. It is also not to be forgotten that in these great depths the magma is probably rich in water and different gases, and consequently fusible at a lower temperature than the 'dry' magmas generally considered. And, lastly, we must also infer with Suess that the fusion of certain parts of the earth's crust may be produced partly by the rising from below of hot plutonic gases. In short, there are sufficient factors for sustaining the hypothesis that in successive geological periods different parts of the solid crust have been caused to melt, and that by this process have been generated the plutonic and volcanic rocks.

When such a refusion, or 'anatexis' as it is called by Sederholm,[1] embraces a portion of the crust, which consists of definite eruptive rocks, e.g. granite, gabbro, basalt, the resulting magma will again be after consolidation the same rock, perhaps only slightly modified by the assimilation of other material during the passage of the magma to the place where it consolidates. But when the re-melted portion of the crust is composed of different rocks, eruptive or sedimentary, or both together, the process is rather a 'syntexis', as I have called it, an assimilation which is followed by liquation and differentiation; the same process of 'syntexis' or assimilation must take place at the margins of such re-melted portions where they are in contact with non-melted portions. Although I am an advocate of the hypothesis of a fluid nucleus, I do not believe that this nucleus would have been (perhaps with a few exceptions) the source of the Archæan and post-Archæan intrusive bodies and superficial volcanic masses; but certainly it must be admitted that different portions of the solid or anatectic crust can be mixed during the process of refusion with fluid material coming from peripheric magmatic basins.

Thus the face of the solid crust, as far as we know it, has been from the Archæan up to the present time often modified and renewed by weathering, sedimentation, fusion, and recrystallization of the material that had formed the crust in a remote pre-Archæan period lying beyond the limits of direct investigation. No wonder that in all post-Archæan periods, as well as in the Archæan, we meet always the same granitic, syenitic, and basaltic rocks, the same gabbros, diabases, porphyries, etc. It is always the same material, perhaps receiving sometimes an admixture from below, which leads under the influence of assimilation to differentiation, and with a tendency to eutectics, resulting always in the same types of eruptive rocks.

The answer to the question put at the beginning of this section would then be the following: The source whence came the igneous rocks, beginning with the Archæan, is the solid earth's crust, different parts of which, periodically re-melted, have been brought to a magmatic state; these magmas in certain cases correspond directly to further rock-types or are brought to these types by differentiation. Originally the oldest igneous rocks were formed from magmatic masses of granite or gabbroidal composition. Such a conception simplifies our problem, and the identity of rock-types in all periods receives a plausible explanation; but it would be difficult to understand and to explain why in all periods the same rock-types were always formed, if we were to assume that every eruptive rock is a part of the fluid nucleus or of a peripheric magmatic basin, solidified for the first time where we find it now.

When I say that we find in the history of the earth a repetition of the same rock-types, I mean the predominating rock-families, as granites, gabbros, pyroxenites, peridotites, syenites, diabases, basalts, porphyries, etc. But, of course, if we take into consideration that the lithological composition of the crust gets more complicated and

[1] J. Sederholm, "Om Granit och Gneiss": Bull. Comm. Géol. Finlande, No. 23, 1907.

that in younger periods the re-melted parts of the crust were more complicated on account of assimilation and differentiation, we must admit that the number of marginal and local facies and of subordinate rare rock-types will increase as we pass from the older periods to the younger.

The hypothesis that the earth's crust has been subject to melting and refusion has been advocated by geologists, beginning with Hutton, who maintained more than a hundred years ago (in 1788) that the sedimentary materials are metamorphosed and even partly melted, being in this way transformed into eruptive rocks when they come into deeper parts of the crust. During the past few years this conception has been largely developed in the studies of Sederholm [1] on the crystalline schists, and in the work of Lukaschewitch,[2] who discerns in sedimentation, subsidence into the deeper parts of the crust, metamorphism, melting, eruption, weathering, and sedimentation, a complete cycle. It is not my purpose to give here an account of the literature on refusion of the crust, but a few examples of such views amongst modern geologists may be cited.

In his well-known Karlsbad discourse Suess has expressed his opinion that the eruptive rocks do not come from a central liquid nucleus, but that they originated by melting of the crust under the influence of ascending hot gases. In the last part of his *Antlitz der Erde* the hypothesis of refusion (*Aufschmelzung*) is developed in the chapter "Die Tiefen".

Branca[3] also supports this hypothesis, although he would restrict the melting to the deeper parts of the crust, the sedimentary rocks not undergoing fusion. Haug's[4] opinion is that sediments are melted in sinking geosynclines; he thinks nevertheless that the presence of alkalies in the eruptive rocks could not be explained in this way, and that it is necessary to admit also a fluid pyrosphere. Haug's views on granite have already been cited. As to his doubts concerning the alkalies, they cease to apply if we assume, as I have done, that the refusion process attacks not only the parts of the crust composed of sediments but also those which are formed by eruptives. Haug's conclusion that it is necessary to admit a fluid pyrosphere is also not the only possible hypothesis, as separate magmatic basins would explain equally well the peculiarities of igneous rocks.

Dolomieu [5] expressed a similar view when he supposed that trachyte was a re-melted granite, because he found granitic enclosures in the trachyte of the Puy de Dôme. Dutton [6] and Schwarz [7] have also considered lavas as re-melted parts of the crust; and very close to the theory of re-melting are the ideas of Delesse [8] and Sterry

[1] J. Sederholm, "Om Granit och Gneiss": Bull. Comm. Géol. Finlande, No. 23, 1907.

[2] O. Lukaschewitch, *The Inorganic Life of the Earth.* Part II, The Life of the Rocks. St. Petersburg, 1909.

[3] Branca, *Centralbl. f. Mineral.*, 1909, p. 135.

[4] E. Haug, *Traité de Géologie.*

[5] Cited by Lacroix, *Mont Pelée*, ii, p. 56.

[6] Dutton, *The High Plateaux of Utah*, 1880, p. 125.

[7] E. Schwarz, "Hot Springs": Geol. Mag., 1907, No. 480, p. 258.

[8] Delesse, *Études sur le métamorphisme*, 1862, pp. 157–220.

Hunt,[1] who considered the plutonic rocks to be due to thermo-metamorphism.

These fragmentary citations show sufficiently well that at different times different authors relying on different considerations have come to the same conception, namely, that the igneous rocks are to be considered as re-melted parts of the solid crust—a hypothesis which seems to me best fitted to resolve in a satisfactory manner the problem of the genesis of igneous rocks not older than the Archæan.

Conclusions.

1. The method hitherto adopted of calculating the average composition of the terrestrial magma must be considered as erroneous in principle.

2. Nevertheless these calculations give a fairly good result, as it corresponds approximately to the mean between gabbro and granite, if we admit that these two magmas enter into the composition of the external part of the earth's crust nearly in equal quantities.

3. Two original independent magmas exist which predominate in the composition of the earth's crust, the granitic and the gabbroidal (basaltic); all the other igneous rocks are derivates from these two and are subordinate to them in their occurrence.

4. Differentiation is produced in two ways: during the crystallization, differentiation by crystallization; and before crystallization, in the liquid magma—magmatic differentiation.

5. The differentiation by crystallization consists in the sinking or rising of the newly-formed minerals according to their specific gravity, and in the solution in one part of the magma (generally a deeper-seated one) of minerals formed in another part.

6. Magmatic differentiation consists in the formation of derived magmas (*Spaltungen*), and is governed by the tendency to form eutectic and monomineral (or bimineral) magmas. This differentiation is induced by the fusion and assimilation of foreign mineral masses, both igneous and sedimentary.

7. Differentiation finds its best explanation in the syntectic-liquational hypothesis (fusion, assimilation, differentiation).

8. All igneous rocks belong to three types: (1) primordial magmas, (2) rocks due to differentiation, (3) rocks produced by mingling of two magmas.

9. The igneous rocks of all geological periods, presumably from the Archæan, originated principally by the refusion of different parts of the earth's crust. On account of this we meet in successive periods always the same types of rocks. The pre-Archæan igneous rocks (perhaps also a part of those of the Archæan and younger periods) were formed from primordial magmatic masses of granitic and gabbroidal composition.

Beaulieu s. Mer.
January, 1911.

[1] Sterry Hunt, "The Origin of the Crystalline Rocks": Trans. Roy. Soc. Canada, ii, p. 3, 1884.

II.—A NEW GENUS OF FOSSIL PLANTS FROM THE STORMBERG SERIES OF CAPE COLONY.

By A. C. SEWARD, F.R.S., Cambridge.

(PLATE XIV.)

THE single specimen which forms the subject of this note was sent to me for examination by Mr. Hewitt, of the Albany Museum, Grahamstown, Cape Colony; it was found at Cyphergat and presented to the Museum by Mr. S. R. Gardner. Fossil plants from Cyphergat in Cape Colony have been described by Feistmantel and, more recently, by myself[1] from beds containing the remains of a flora assigned to the Rhætic age. Our knowledge of this flora is based on material obtained from the Molteno Beds at the base of the Stormberg Series[2] at Molteno, Stormberg, Cyphergat, and other places.

The fossil shown natural size in Pl. XIV, Fig. 1, may be described as follows: A partially carbonized impression of a portion of a bipinnate frond 11 cm. long, consisting of a comparatively slender rachis not exceeding 3 mm. in breadth, which gives off sub-opposite linear pinnæ at an angle of approximately 45°. The pinnæ bear alternate broadly linear pinnules attached by a short stalk; the substance of the lamina is represented in places by a fairly thick carbonaceous layer. The apex of the pinnules is bluntly rounded, and at the proximal end the edge of the lamina bends inwards rather abruptly towards the stalk (Pl. XIV, Figs. 1, 1*a*–*c*). There is a well-defined midrib, from which a few simple or forked veins arise at a wide angle.

The preservation is far from satisfactory, but the thickness of the carbonaceous layer, as seen in some of the pinnules (e.g. Pl. XIV, Fig. 1*a*), indicates a thick lamina. A superficial examination of the specimen suggested comparison with *Bernoullia helvetica*, Heer, a species originally described by Heer[3] from the Upper Triassic beds of Switzerland, and more recently figured by Leuthardt[4] from the Keuper of Neuewelt near Basel. Professor Zeiller[5] has also described the same type from the Rhætic flora of Tonkin. The fertile pinnules of *Bernoullia* are in some cases contracted at the base, and in this respect approach the more definitely stalked segments of the Cyphergat plant; but a more careful examination of the published figures and of a Swiss specimen kindly given to me by Dr. Leuthardt convinced me that the fossils are generically distinct. They differ in the shape of the pinnules as in the venation; in *Bernoullia* the secondary veins are numerous, while in the South African plant they appear to be few and widely separated. Moreover, in the plant shown in Pl. XIV, Fig. 1, the stalked pinnules are sterile, and differ considerably from

[1] Feistmantel, *Abh. kön. böhm. Ges. Wiss.* [vii], Bd. iii, 1889; Seward, Ann. S. African Mus., vol. iv, 1903.

[2] Rogers & Du Toit, *An Introduction to the Geology of Cape Colony*, London, 1909.

[3] Heer, *Flor. Foss. Helveticæ*, p. 88, pl. xxxviii, figs. 1–6, Zürich, 1876.

[4] Leuthardt, *Abh. Schweiz. paläont. Ges.*, vol. xxxi, p. 38, pl. xix, figs. 1–4; pl. xx, figs. 1, 2, 1904.

[5] Zeiller, *Flor. Foss. Gîtes de Charbon du Tonkin*, p. 34, pl. i, figs. 14–16, Paris, 1903.

T. A. Brock del.

Stormbergia Gardneri, gen. et sp. nov. Stormberg Series, Cyphergat, Cape Colony.

the sterile segments of *Bernoullia*. Among recent ferns stalked pinnules occur not infrequently, e.g. in species of *Adiantum*, *Pellæa*, *Llavea*, *Polybotrya*, *Osmunda*, *Didymochlæna*, and other genera, but it is noteworthy that among fossil Ferns and Pteridosperms stalked pinnules are very uncommon. One of the few examples known to me is *Neuropteris Grangeri*, a species originally described by Brongniart[1] from the Coal-measures of Ohio, and more recently figured by Zeiller[2] from France. In this Upper Carboniferous species the pinnules possess the venation and auriculate base characteristic of *Neuropteris*, and differ widely from those shown in Fig. 1.

It is unfortunate that the South African plant is represented only by a single specimen, and that an imperfect one. While venturing to institute a new genus, I hope that additional material may be obtained which will lead to a more satisfactory knowledge of the affinity of the plant. In the absence of fertile specimens the question of taxonomic position cannot be definitely settled, though the presumption is that the frond is that of a fern.

STORMBERGIA, gen. nov. Plate XIV.

Fronds characterized by pinnules with the *Cladophlebis* type of venation, attached to the pinnæ by a short stalk. The lamina is suddenly contracted at the base and not auriculate.

STORMBERGIA GARDNERI, gen. et sp. nov. Pl. XIV, Figs. 1, 1*a–c*.

The specific characters are enumerated in the description already given. The specimen was discovered by Mr. S. R. Gardner in the Stormberg Series at Cyphergat, Cape Colony.

III.—On the Occurrence of Beds of the Yellow Sands and Marl in the Magnesian Limestone of Durham.

By R. Cooksey Burton, B.Sc., Armstrong College.

DURING an investigation of the 'Yellow Sands' and Magnesian Limestone of Durham and Northumberland, several lenticular and irregular hollows or caverns, containing 'Yellow Sands' and light yellow marl, were noticed in the Lower Brecciated Magnesian Limestone at Trow Rocks, about one mile south of the Tyne (see Map, Fig. 1).[3]

The 'Yellow Sands' and marl in some cases are found as separate beds, whereas in others they are mixed together irregularly. The

[1] Brongniart, *Hist. Vég. foss.*, p. 237, pl. lxviii, fig. 1, Paris, 1828.

[2] Zeiller, *Bassin Houill. et Perm. d'Autun et d'Epinac*, p. 145, pl. xi, figs. 6, 6*a*, Paris, 1890.

[3] The classification of the Permian adopted in this paper is as follows :—

7. Upper (Concretionary) Magnesian Limestone.
6. Upper Middle Magnesian Limestone.
5. Brecciated Magnesian Limestone of irregular thickness.
4. Disturbed beds of Lower Limestone.
3. Undisturbed Beds of Lower Limestone.
2. Marl Slate.
1. Yellow Sands.

The 'Yellow Sands' lie unconformably on the Coal-measures.

'Yellow Sands', even when regularly bedded, contain a considerable amount of calcareous marly material, being in this respect rather different from the 'Yellow Sands' as they outcrop in the normal position beneath the Marl Slate and Magnesian Limestone. When, however, the sand from these included beds is washed with acid, there is no difficulty in recognizing the well-worn and rounded grains of the typical wind-blown 'Yellow Sands'.

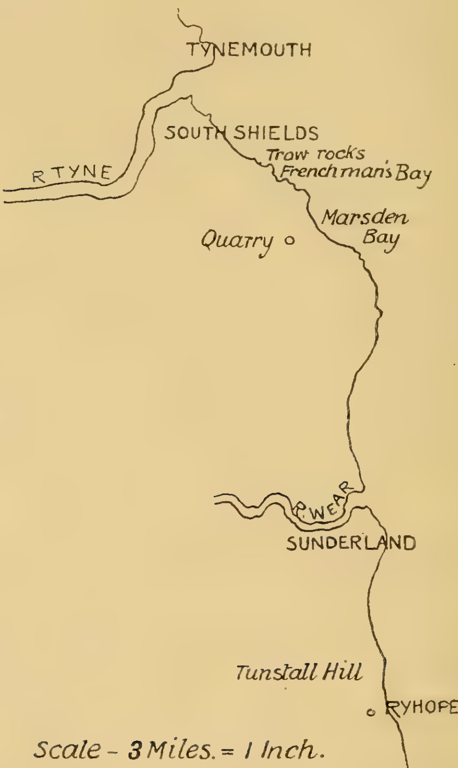

FIG. 1. Sketch-map showing places mentioned in this paper.

The manner in which the deposits occur in the breccia is difficult to describe, as they are very variable in shape; but it will be convenient to recognize three classes—

1. 'Yellow Sands' and yellow marl occurring in small pockets and hollows in the Breccia.

2. Irregular beds lying in horizontal and nearly vertical and parallel fissures, all filled with 'Yellow Sands' mixed with marl in various proportions.

3. Lenticular and cavernous hollows filled by alternating beds of 'Yellow Sands' and marl.

1. The small pockets and hollows are of various dimensions, having a diameter from 2 to 5 inches; these pockets form a network simulating an irregular honeycomb structure. In these small pockets the sand and marl are irregularly mixed together, so that no regular bedding can be distinguished.

2. The second type is shown in Fig. 3, where highly inclined parallel fissures are connected with the main horizontal fissure. The included beds consist mainly of impure 'Yellow Sands', becoming more marly towards the ends. The bedding is conspicuous and conforms very noticeably to the irregular roof.

3. Fig. 4 shows a section of the thickest and most extensive of the lenticular beds of 'Yellow Sands'; its total thickness is 4 feet and its length slightly more than 20 feet; it is remarkable as showing alternations of sand and marl in well-bedded horizontal layers and in presenting a well-marked case of false bedding in the sand (see A, Fig. 4). The marl is quite moist and soft and contains a considerable amount of common salt. The water pumped up from considerable depths in the Permian is generally salty, and its specific gravity sometimes approaches that of sea-water.

The area over which these peculiar included beds of 'Yellow Sands' are scattered is fairly extensive, and the fact that both in the north–south and east–west sections their shape is lenticular is an argument in favour of their occupying cavern-shaped hollows in the breccia. More than a dozen of these pockets filled with sand and marl are scattered over the Trow Rocks area.

The 'Yellow Sands' as they occur in situ beneath the Marl Slate consist of well-polished and rounded grains of quartz coated with oxides of iron, which give to the sand various colours from light yellow to dark brownish-red according to the percentage and state of hydration of the iron oxide. The sand from the above pockets and lenticular beds was identified with certainty as true 'Yellow Sands' not only by the rounded nature of the grains, but also by a comparison of the percentage of its heavy minerals with that peculiar to the 'Yellow Sands' occurring in their natural position at Frenchman's Bay, half a mile to the south.

The 'Yellow Sands' all along their outcrop contain varying percentages of heavy minerals having a specific gravity greater than 2·80; these were determined by the use of Sonstadt solution in Sollas's separating funnel. At Frenchman's Bay the percentage of heavy residue is 0·17 per cent., while in the Trow Rocks 'Yellow Sands' it is 0·2 per cent.; in each case the heavy minerals are similar, being mainly garnet, tourmaline, zircon, rutile, and ilmenite, with leucoxene.

It is thus established that the sand occurring in the pockets in Magnesian Limestone at Trow Rocks is identical with the bed of 'Yellow Sands' which occurs in place at Frenchman's Bay between tide-marks. The light-yellow marl is a mixture of calcium and magnesium carbonates containing clayey matter in varying quantities. So far as our knowledge extends at present the 'Yellow Sands' are invariably accompanied by the Marl Slate when in their natural position, being directly under this group of beds, which occurs at the base of the

Magnesian Limestone. In the present instance, however, the Marl Slate is absent for reasons given in detail below. At Frenchman's Bay the 'Yellow Sands' outcrop about 20 feet below the level of the cliff foot, and at Trow Rocks the above-mentioned included beds of 'Yellow Sands' occur at various heights (4–30 feet) above the base of the cliff, so that these beds are sometimes as much as 50 feet above their natural position. The following are possible explanations of their mode of formation:—

1. The sand may be the residue left on the solution of the Magnesian Limestone.

2. The sand may have been carried up from beneath the Marl Slate by the thrusting movements.[1]

3. The beds may be a later deposit of 'Yellow Sands' laid down in the positions in which we now find them.

4. They may have been carried up from below by the action of underground water.

We will deal with these suggestions in order.

1. While studying the mineralogical composition of the 'Yellow Sands' we have examined many samples of Magnesian Limestone, and in some cases they have been proved to contain quartz grains and various heavy minerals, which we hope to describe at some future date. These Magnesian Limestone grits occur at Rocky Crag, Tunstall Hill, in the form of a vertical dyke-like mass, at Marsden Quarry as a horizontal bed in the Middle Magnesian Limestone, and in a cave in Marsden Quarry about 40 feet above the level of the last. In all these cases, however, the residue left from the limestone after treatment with acid consists of angular and rounded grains of various sizes from $\frac{3}{16}$ inch to microscopic proportions; the angular grains are among the largest, and consist of quartz, chalcedony, and chert. This sand is evidently not wind-blown but deposited by water, and could not be mistaken for the 'Yellow Sands', since in the latter the largest grains are perfectly rounded and abraded; the smaller grains of the 'Yellow Sands' are sometimes quite angular. This, however, is in accordance with Sorby's statement that the smallest grains in a sand are always the most angular, as they present only a small surface for abrasion. It is thus evident that the beds of 'Yellow Sands' are not insoluble residues left on the solution of the Magnesian Limestone. As regards the origin of the chert in these sandy residues, it may be stated that we have lately discovered in the brecciated Magnesian Limestone, nodules, irregular beds, and brecciated pieces of chert. On the coast half a mile north of Ryhope a thin brecciated bed of white chert occurs 30 feet long and 6 inches thick; it is irregular and forms part of the breccia, although not so strongly brecciated as the limestone owing to its being of stronger material.

[1] The effects of the horizontal thrust on the Permian of this area have been fully described by Dr. Woolacott in Memoir No. 1, Durham University Philosophical Society. For our purposes it is sufficient to state that considerable horizontal movement of the upper beds of limestone has taken place over the lower, causing brecciation of the lower and middle Magnesian Limestone; part of the lower limestone lying under the thrust-plane is slightly disturbed, but remains unbrecciated.

At Marsden large angular blocks of white chert, sometimes 9 inches in diameter, have been found, and at Trow Rocks smaller pieces of white and also black chert are met with. It is worthy of note that this chert is always seen in the Middle Brecciated Magnesian Limestone; this, coupled with the facts above mentioned, proves that the chert is of pre-Thrust age and probably contemporaneous with the limestone.

2. The second suggestion is untenable, since the sand and marl could not have been carried up during the movement of the rocks caused by the thrusting, because the beds are quite undisturbed, regularly bedded, and laminated; moreover, the existence of false-bedding in the sand points to deposition in water disturbed by only slight currents.

3. At first sight this theory seems to be plausible, the more so because at Tynemouth Cliff we find beds of 'Yellow Sands' above the lower beds of Magnesian Limestone. Below is a sketch of the Tynemouth Cliff section, showing the position of the later beds of 'Yellow Sands'.

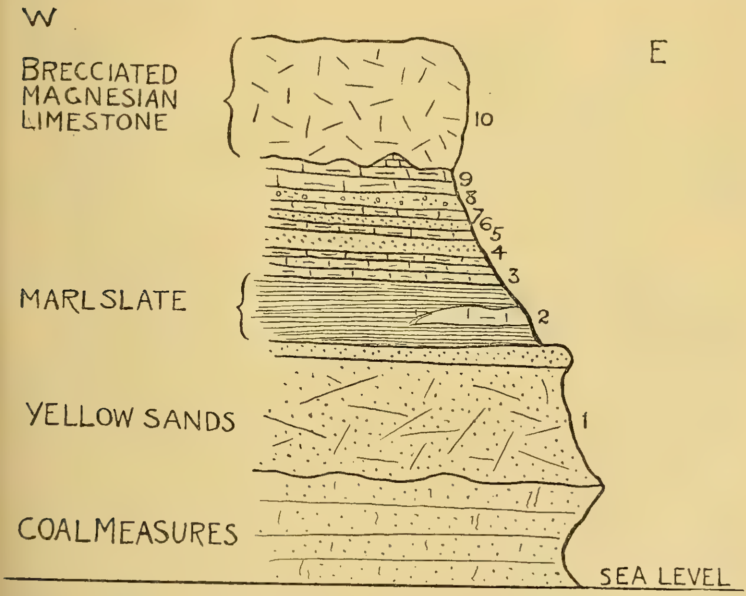

FIG. 2. Section of Tynemouth Cliff. 1, Lowest bed of Yellow Sands, 12 feet; 2, Marl Slate, 4 feet; 3, Thin-bedded Magnesian Limestone; 4, Yellow Sands, 2 feet; 5, Thin Magnesian Limestone; 6, Yellow Sands, 3 inches; 7, Thin Magnesian Limestone; 8, Uppermost bed of Yellow Sands, 1½ feet; 9, Bedded Magnesian Limestone; 10, Brecciated Magnesian Limestone, 20 feet.

This section has been frequently misinterpreted; in Sedgwick's paper on the Geological Relations and Internal Structure of the Magnesian Limestone[1] the Marl Slate is represented as overlying certain beds

[1] Q.J.G.S., ser. II, vol. iii, pl. vi, fig. 1, 1835.

of Magnesian Limestone; this, however, is not the case, the Marl Slate is here in its proper position above 'Yellow Sands', but is itself overlain by later beds of 'Yellow Sands' separated by thin beds of Magnesian Limestone. The correct section is shown in Fig. 2. The uppermost bed of 'Yellow Sands', No. 8, is very compact and should rather be termed a Magnesian Limestone grit or conglomerate; it consists of large and small grains and pieces of more compact 'Yellow Sands' cemented into a solid rock by a dark-yellow cement of magnesium and calcium carbonates; it represents the latest stage of the deposition of 'Yellow Sands', and was probably produced by 'Yellow Sands' being blown and otherwise carried into water, in which the deposition of Magnesian Limestone was proceeding. A local unconformity between the 'Yellow Sands' and Magnesian Limestone is therefore proved at this point. The

Fig. 3. Fissures in the Magnesian Limestone containing Yellow Sands. Dotted portion, Yellow Sands; shaded portion, Marl predominating; bedded sand at X, Y, Z. Length of section, 15 feet; thickness of sand at X, 1½ feet; cross-hatching, Brecciated Magnesian Limestone.

occurrence of these beds of sand, Nos. 4, 6, and 8, above the Marl Slate and also above certain beds of Magnesian Limestone proves that the formation of 'Yellow Sands' proceeded, perhaps intermittently, during the deposition of the limestone; thin beds of 'Yellow Sands', one inch thick, sometimes occur between the bedding-planes of the limestone just above the Marl Slate, but they rapidly thin out to nothing.

4. We will now discuss the last and most satisfactory explanation of the occurrence of these secondary beds of 'Yellow Sands'. This series, as has been shown by many writers,[1] is a great water-bearing system, and is the source of the water-supply of Sunderland and most

[1] Professor Lebour, Trans. N. of England Inst. Min. Eng., vol. xxiv, p. 370, 1902–3.

of the neighbouring region. Now when the thrust[1] acted on the Permian rocks of this area the Magnesian Limestone and Marl Slate were much disturbed, brecciated, contorted, and pinched out in various ways; fissures were produced, much shearing and slickensiding took place, and opportunities for the circulation of water were greatly increased. At Trow Rocks the thrust-plane can be seen at the north end of the quarry dipping to the south, and we find brecciated Magnesian Limestone overlying unbrecciated beds beneath the thrust-plane. The Marl Slate and 'Yellow Sands' cannot be seen in situ, being below tide-mark, and the effect of the thrust on those beds cannot be exactly determined at this point. The Marl Slate is a relatively impermeable bed, and would, no doubt, in its normal

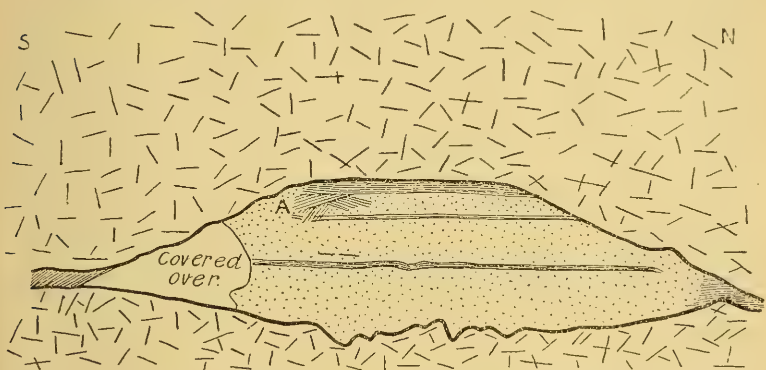

FIG. 4. Section of lenticular hollow in the Magnesian Limestone, containing Yellow Sands. The Marl beds are 2 inches to 3 inches thick; total thickness of lenticular bed, 4 feet; total length of lenticular bed, 20 feet.

condition prevent the circulation of much water through it. The Marl Slate at Trow Rocks must therefore have been so fractured and possibly brecciated by the thrusting movements that water could freely percolate through it and through the joints. In many sinkings made in the North of England Permian water in large quantity has been struck, and in its rise from below has carried up large amounts of 'Yellow Sands'; it is thus that the lenticular beds of sand and marl in the Magnesian Limestone have been formed. Subsequent to the brecciation of the rocks percolating water has excavated hollows in the breccia; underground water has accumulated to heights of at least 50 to 60 feet above the 'Yellow Sands', and, being probably subject to rises and falls for some unknown reasons, has carried up with it quantities of the loose sand and deposited it in the above-mentioned hollows and caverns, and thus formed secondary beds of 'Yellow Sands'.

In all cases the beds of 'Yellow Sands' and marl conform to the irregular surfaces of the limestone and also quite fill the hollows,

[1] Dr. Woolacott, "A case of Thrust and Crush-brecciation in the Magnesian Limestone of County Durham": Univ. Durham Phil. Soc., Memoir No. 1.

so that the water carrying the sediment must have quite filled the hollows. The secondary beds are found as much as 50 feet above the outcrop of the 'Yellow Sands', so that the underground water must have risen to at least this height and have filled the joints, fissures, and caverns in the limestone breccia. Some of the sand beds contain angular blocks of breccia, which have doubtless fallen from the roof of the cavern during the deposition of the secondary beds. The thrust-plane mentioned above was seen to affect only the upper beds of the lower limestone, while the beds beneath were unbrecciated; the Marl Slate is thus probably unaffected by this thrust-plane, being several feet below it. We have seen that the Marl Slate must be disturbed and fractured, and in order to account for this we may assume the existence of a second thrust-plane beneath the first along which the Marl Slate and possibly lower beds have been set in motion and fractured. The section from the Tyne southwards shows many interesting breccias, and at Trow Rocks evidence can be obtained proving that at least two series of thrust movements, and possibly three, have affected the Permian of this area. In the first place some pieces of breccia contain within them angular fragments of breccia produced by a previous thrust-movement; the limestone was first brecciated, and the breccia, having been cemented into a compact rock, was subsequently broken up by a second series of movements. Moreover, the breccia as a whole is traversed in some places by a series of joints, reversed faults, and other slickensided planes of movement, which may have been formed during a third movement of the beds in a horizontal direction. The thrust-plane, which affects the Magnesian Limestone and is seen dipping south at the north end of Trow Rocks, probably crosses the Marl Slate somewhere to the south of Trow Rocks; the 'Yellow Sands' in the pockets may therefore have been carried up by water from this point and not from a place immediately below their present position; it would then be unnecessary to assume a second thrust-plane to account for this phenomenon, but the occurrence of the above-mentioned doubly brecciated rocks renders it probable that there is a second thrust-plane in the Coal-measures or in the Lower Permian beds.

The whole question of the origin of marl pockets in the Magnesian Limestone may be affected by the discovery of the above secondary beds of 'Yellow Sands'.

Bedded 'Yellow Sands' in marl pockets have not before been proved; moreover, the existence of pockets, as at Marsden, containing marl and angular sand-grains renders it probable that many marl pockets are of secondary origin due to solution of the limestone, and the subsequent washing in of marl and the insoluble residue left on solution of the limestone. Many marl pockets are, of course, original and are particularly rich in Permian Gasteropods and Foraminifera; such pockets are known at Tunstall Hope and have yielded, among others, specimens of *Textularia* and *Turbo Taylorianus*.

In conclusion I desire to express my thanks to Professor Lebour and Dr. Woolacott for their well-timed criticism and encouragement.

IV.—On a New Species of *Eryon* from the Upper Lias, Dumbleton Hill.

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

VARIOUS forms of Macrourous Decapod Crustacea referable to the genus *Eryon* have attracted my attention from an early date,[1] and in the Geological Magazine for 1888[2] I gave a summary of all the then known species. The following seven species are British:—

Eryon (*Coleia*) *antiquus*, Broderip, sp., 1840. Lower Lias, Lyme Regis.
E. Barrovensis, M'Coy, 1849. Lias, Barrow-on-Soar.
E. Brodiei, H. Woodw., 1866. Lower Lias, Lyme Regis.
E. crassichelis, H. Woodw., 1866. Lower Lias, Lyme Regis.
E. Wilmcotensis, H. Woodw., 1866. Lower Lias, Wilmcote.
E. Moorei, H. Woodw., 1866. Upper White Lias, Ilminster.
E. Stoddarti, H. Woodw., 1881. Stonesfield Slate, Oxfordshire.

The sixteen species given below are all foreign:—

Eryon Escheri, Oppel, 1862. Lower Lias, Schambelen, Switzerland.
E. Edwardsi, Moriere, 1864. Upper Lias, Calvados.
E. Calvadosi, Moriere, 1883. Upper Lias, Calvados.
E. Hartmanni, v. Meyer, 1862. Upper Lias, Boll, Würtemberg.
E. Perroni, Etallon, 1858. Oxfordian, Haute Saône.
E. arctiformis, Schlot., 1820.
E. bilobatus, Münst., 1839.
E. elongatus, Münst., 1839.
E. longipes, Fraas, 1855.
E. Oppeli, H. Woodw., 1866.
E. orbiculatus, Münst., 1839.
E. propinquus, Schlot., 1822.
E. Redenbacheri, Münst., 1839.
E. Schuberti, v. Meyer, 1836.
E. spinimanus, Germar, 1827.
} Kimmeridgian Group, Lithographic Stone, Solenhofen.
E. Neocomiensis, H. Woodw., 1881. Lower Cretaceous, Silesia.

I have recently received from Mr. Linsdall Richardson, F.R.S.E., F.G.S., the Honorary Secretary of the Cotteswold Naturalists' Field Club, Cheltenham, a specimen of *Eryon* from the Upper Lias of Dumbleton Hill, near Beckford, Gloucestershire (see Fig. 2), which appears to represent a species of that genus new to this country, but closely allied to a small group comprising three species, namely, *Eryon propinquus*, Schlot., sp., *E. orbiculatus*, Münst., and *E. elongatus*, Münst., all from the Lithographic Stone of Solenhofen, in Bavaria, and of Kimmeridgian age, characterized by the more rounded form of their carapaces when compared with such species as *E. Barrovensis*, M'Coy, *E. Brodiei*, H. Woodw., *E. antiquus*, Broderip, sp., and *E. arctiformis*, Schlot., sp.

We subjoin a figure of the under-side of *Eryon propinquus*, Schlot., sp. (Fig. 1), from the Lithographic Stone of Mörnsheim, near Solenhofen, Bavaria (see Oppel's *Pal. Mittheil.*, 1862, tab. i, fig. 2). In this specimen all the appendages are most beautifully preserved—indeed, quite as well as in a living form. Two specimens, almost equally perfect, may be seen in the Haberlein Collection, also from the Lithographic Stone of Solenhofen, in the British Museum (Nat. Hist.), Department Geology, Gallery VIII, Wall-case Crustacea.

[1] See Quart. Journ. Geol. Soc., vol. xxiii, p. 493, pls. xxiv, xxv, 1866.
[2] pp. 433–41, Pl. XII and Text-figs.

Dr. W. T. Calman[1] places the Eryonidea under the

Sub-order 2. REPTANTIA, Boas (1880).

"Body not compressed, often depressed; rostrum often absent, depressed if present; first abdominal somite distinctly smaller than the rest; legs strong, the first pair usually, the others never, stouter than their fellows, basipodite and ischiopodite almost always coalesced in the first pair, generally also in the others, two fixed points in the carpo-podal articulation, exopodites never present, podobranchiæ often on some of the first four pairs; male genital apertures on coxopodites or on sternum; pleopods often reduced or absent, not used for swimming."

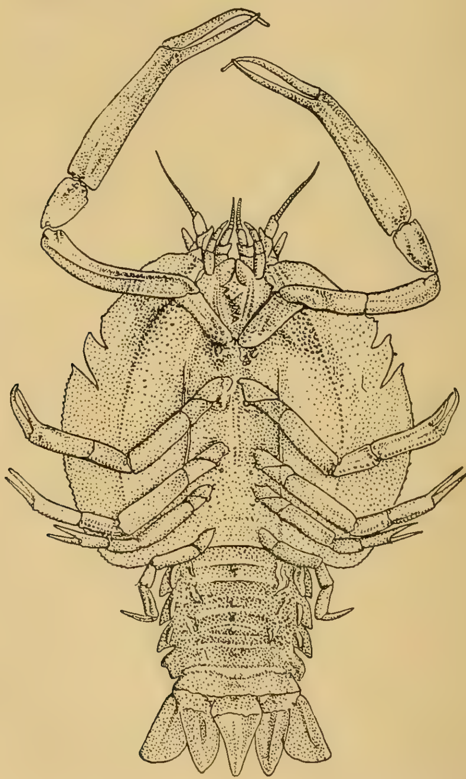

FIG. 1. *Eryon propinquus*, Schlot., sp. Lithographic Stone: Solenhofen, Bavaria.

[Reproduced by permission from Sir Ray Lankester's *Treatise of Zoology*, pt. vii, Appendiculata, fasc. iii, Crustacea, by Dr. W. T. Calman, p. 308, fig. 185.]

Section 1. PALINURA.

Tribe 1. ERYONIDEA.

"Antennæ with exopodite, first segment not fused with epistome, first four pairs, or all the legs, chelate, first pleopods present."[1]

[1] See in Lankester's *Treatise of Zoology*, pt. vii, Appendiculata, fasc. iii, Crustacea, by W. T. Calman, 1909, p. 312.

Condition of the specimen.—The Dumbleton specimen is a natural counterpart of the under-side of the carapace, carrying with it the greater part of the test, and thus exposing an inner view of it and of the three anterior segments of the abdomen attached to it; the minute punctate ornamentation of the surface being caused by the observer

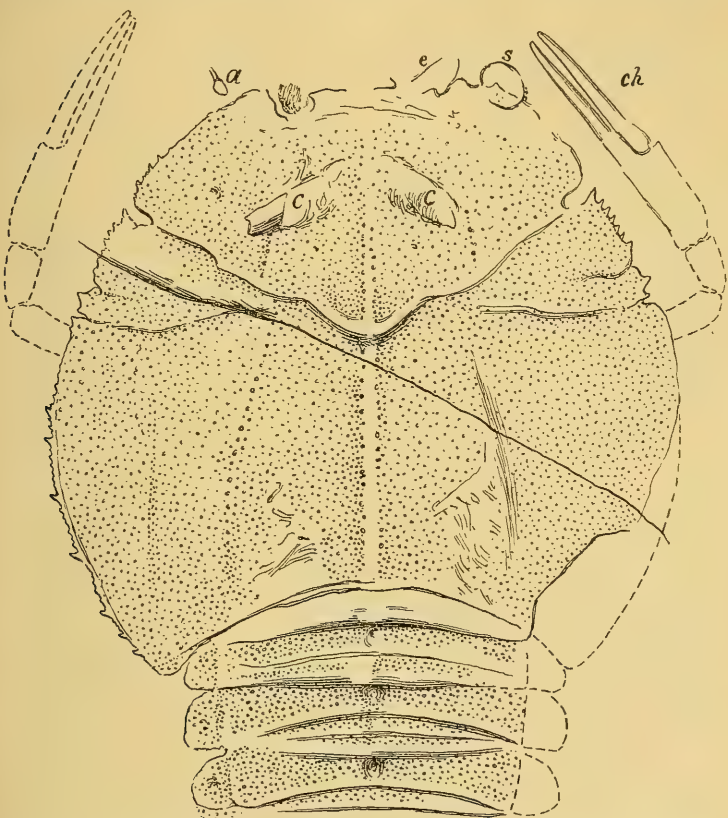

FIG. 2. *Eryon Richardsoni*, sp. nov. Nat. size. Upper Lias: Dumbleton Hill, near Beckford, Gloucestershire. *a*, portion of one of the antennules detached; *e*, scale at base of right antenna; *s*, section of a broken limb detached and displaced; *c*, *c*, part of basal joints of large chelæ; *ch*, portion of large chela on right side (the missing parts of both chelæ are restored in dotted lines).

seeing the under-side of the finely tuberculated free surface, which is still partly adhering to the matrix and partly to the other corresponding slab which is evidently missing. The breadth of the carapace is rather greater than the length, its contour being nearly circular; the posterior border is arcuate and broadly incurved, the postero-lateral border is rather contracted, and its angles slightly produced backwards. The margin along the branchial region is entire, broadly and gently rounded, its border finely serrated, having five or six rather larger spines at irregular intervals. The carapace contracts slightly in breadth towards the cervical ridge[1] where the first marginal indentation is seen, in front of which is a small, rather obtuse, marginal tooth, marked by a slight notch in front and by a branch of the cervical 'furrow' behind; this is succeeded (anteriorly) by a second roundly incurved marginal tooth, twice the breadth of the last one, with a rounded border and sharply pointed spine directed forwards and marked off anteriorly by a well-defined notch and by the superior branch of the cervical 'furrow'.[1] The margin again expands slightly, and then curves rapidly inwards until it forms with a spine the outer angle of the orbital fossa. The anterior frontal border (with the antennules and antennæ) has been much crushed and can only be imperfectly defined. The eyes are not preserved, but on the right side there is a portion of one of the large chelæ seen in section lying in the orbital fossa (*s*). Width of the anterior border of carapace, 3 cm.; width across the broadest part of the carapace (behind the cervical ridge[1]), 9 cm.; width at posterior border, 6 cm.; length of carapace along the dorsal line, 7 cm. The cervical ridge occupies its centre and forms a concave curve backwards 15 mm. in breadth, being $3\frac{1}{2}$ cm. behind the anterior and $3\frac{1}{2}$ cm. in front of the posterior border. It bifurcates at 10 mm. on either side of the dorsal line, enclosing between its branches the two tooth-like serrations on the lateral border. Two curved furrows[2] cross the posterior portion of the carapace, the inner pair at 15 mm. distance on either side of the straight dorsal line at the hinder border, but converging to 10 mm. at the cervical furrow; the outer pair are more faintly marked. The dorsal ridge and the two lateral lines nearest to the dorsal line (marked by slightly larger tubercles) extend from the cervical furrow to the anterior margin of the carapace.

Traces of the basal joints of the large anterior pair of chelate legs are seen on the anterior part of the carapace at *c*, and one of the chelæ is seen upon the slab in its normal position (*ch*). The three anterior abdominal segments still remain attached to the cephalo-thorax, and measure together $3\frac{1}{2}$ cm. in length and 5 cm. in breadth. Each segment is broadest near its margin, and is strongly corrugated transversely, the back and front ridges of each segment converging on the dorsal line, and each segment is marked by a very prominent tubercle which we see as a hollow on the under-side. These transverse ridges and furrows give attachment to the muscles for flexing the abdominal segments and the rhipidura or tail-fan in swimming. The central portion of each segment is ornamented with minute tubercles, but the interlocking and overlapping anterior and posterior borders are smooth.

[1] This would, on the exposed upper surface of the carapace, be seen to be a furrow, but is here seen from beneath as a ridge.

[2] But for the fact that we are looking at the under-surface, both the dorsal and lateral furrows would appear as ridges upon the upper surface of the carapace, whilst the cervical furrow (which is really a furrow) appears as a ridge when seen from underneath.

When compared with other species of the genus, so far as its imperfectly preserved condition admits, we notice that the Dumbleton specimen (Fig. 2) has a small additional posterior tooth upon the margin of the carapace near the cervical furrow, and that the cervical furrow is distinctly bifurcated. This is seen to be the case in *Eryon Moorei*, H. Woodw. (Q.J.G.S., vol. xxii, p. 499, pl. xxv, fig. 3, 1866), in *E. Brodiei*, H. Woodw. (op. cit., p. 498, pl. xxiv, fig. 2); probably also in *E. crassichelis*, H. Woodw. (op. cit., p. 497, pl. xxv, fig. 2), and in the recent *Pentacheles euthrix*, W. Suhm, "Challenger" Report (see also Geol. Mag., 1888, p. 439, fig. 2), but not noticeable in the other species of this genus.

Although the above characters may be considered minor distinctions, yet, taken along with the fact of the extremely rounded contour of the carapace in the Dumbleton specimen (Fig. 2), a feature observed only in three, or possibly four, other species (for *E. crassichelis* may perhaps also have had a rather circular carapace), and being probably the first of these circular forms of *Eryon* observed in our English Lias, I venture to designate it as *E. Richardsoni* after its discoverer, Mr. Linsdall Richardson, F.R.S.E., F.G.S., the energetic Secretary of the Cotteswold Club, to whom I am indebted for the opportunity to figure and describe it.

The specimen is to be placed in the Cheltenham Town Museum, and forms a part of the 'Holland Collection'.

REVIEWS.

I.—A New Vulcanology.[1]

(*Concluded from the June Number, p. 273.*)

We now come to the portion of the book which will attract most attention, the portion, that is, which deals directly with the function of water in volcanic phenomena. An account is given of the methods employed in the *quantitative determination of water in natural volcanic emanations.* Two methods are used in the field—(1) condensation, (2) hygrometry. Specimens are also taken in sealed tubes to the laboratory, and there examined either hygrometrically or by absorption over phosphoric anhydride.

The wealth of experimental and observational data which follows may be illustrated by a few selected examples. Brun's main thesis is that paroxysmal eruptions are *anhydrous*, while solfataric eruptions owe their *aqueous* character solely to the invasion of volcanic foci by superficial waters as soon as the temperature of the latter falls sufficiently.

A summary of observations made at *Vesuvius* in April, 1906, may be taken as typical.

1. Near the crater the ashes fell quite dry. They continually gave rise to avalanches, and once they were mixed with the air in this manner they entrapped myriads of bubbles, forming an emulsion which

[1] *Recherches sur l'exhalaison volcanique*, by Albert Brun, Chemist, L.Sc.Ph. Sorbonne, D.Sc.Ph. (*honoris causa*) Geneva. A large quarto volume, 227 pages, 16 text-figures, 27 photographic plates, and 7 panoramas. Price 30 francs.

settled with extreme slowness. Photographs show the author wading through such emulsions well over his ankles. At a distance from the crater, for example at Pompeii, the ash fell with 0·1 per cent. water and was sufficiently moist to retain a finger-print. This increasing water content depends upon the presence of the hygroscopic chlorides $Fe\,Cl_2$, $Mg\,Cl_2$, etc. Where it has 0·2 per cent. water the ash agglutinates into little spheres. The hygroscopic character of the ash is well shown by the following experiment. After careful drying the ash is exposed to a moist atmosphere saturated at 20° C. (P. = 730 mm.). It absorbs—

In 5 minutes	. . . .	0·13 per cent. of water.
,, 15 ,,	. . . . .	0·30 ,, ,,
,, 60 ,,	. . . . .	0·90 ,, ,,

Those who maintain the orthodox aqueous theory of volcanic explosions must suppose that the ash falling near the crater was too hot during its transit to absorb any of the water-vapour by which it was propelled. This involves another difficulty: the ash when it falls is white, but it can be shown experimentally that owing to its content of ferrous chloride, it reddens immediately if exposed to the action of water-vapour at a high temperature.

2. In the mass of the cone and in the crater the salts $Fe_2\,Cl_6$, $Fe\,Cl_2$, $Mg\,Cl_2$, and $Al_2\,Cl_6$ may be collected dry and undecomposed, although at low temperatures they are deliquescent, while at 300° C. water-vapour transforms them instantaneously into $Fe_2\,O_3$, $Mg\,O$, and $Al_2\,O_3$.

3. One day during the eruption drops of moist clay did indeed fall at Resina; at other places, however, the ash was dry. The local nature of the phenomenon points to the atmosphere as the source of the water in this particular case. The very darkness due to a cloud of ash is in itself a provocative cause of rain, owing to the fall in atmospheric temperature involved; thus Brun and Montagnier have observed drops of clay during a sandstorm at the Bay of Peneda, Lanzarote, one of the Canary Islands, whither we may now follow our indefatigable guide.

Brun went to the Canaries with Montagnier on purpose to study volcanoes in a typical arid region. Solfatara were found on the *Sugar Loaf* of Tenerife. Those of the crater had a temperature of 83° C., and liberated gases which, when deprived of water, had a percentage volume composition of about 67 per cent. $C\,O_2$, 4 per cent. O_2, and 29 per cent. unabsorbable gases (nitrogen, etc.). The water saturated the fumaroles after showers of rain, and in fact occurred as drops carried in the stream of gas; at other times its amount was insufficient to maintain saturation.

Timanfaya, in Lanzarote, proved exceptionally interesting. Rain falls but once a year in this island, and at the time of Brun's visit, in mid-September, 1907, the last rain had fallen on April 27, and had continued for four hours only.

The cone of Timanfaya is a mass built up of lapilli, dating from the eruption of 1730–6, and is still warm (1907). Where the temperature is highest the pebbles are cemented into a reddened crust 10 cm. deep. The base of this crust is covered with a thin green layer of ferrous chloride, and has a temperature of about 140° C. Below there occur black lapilli covered with a white saline crust. At 60 cm. the temperature is already 360° C.

There are no fumaroles. Burying the tubes as deeply as possible in the lapilli, the gas pumped up proved to be nothing but air with a trace of carbon dioxide and ammonia. The dew-point of the air thus obtained was 16° C., that of the atmospheric air at the same locality 16°·5 C. This experiment, and the preservation of the ferrous chloride on the lapilli, afford evidence that the volcano, though hot, is exhaling no water. As it is scarcely exhaling any vapour or gas at all this observation is in a sense negative, but it can scarcely be doubted that were Timanfaya transported to a humid region it would give rise to the commonplace solfataric phenomena.

Once again the scene changes as we follow our explorer to the soaking tropical region of Java. As before only a few selected observations can be mentioned. The giant *Semero* is climbed. The destructive deluges of mud which descend its slopes are only indirectly volcanic in origin. Since its recent reawakening Semero has cleared its upper slopes of vegetation and thus has given a free hand to pluvial erosion.

The great white cloud of the volcano slowly drifts out of sight beyond the horizon. It is insoluble in the atmosphere and therefore consists of solid particles, not of condensed water-vapour. This is a point Brun emphasizes repeatedly in connexion with active volcanoes in general. It has, however, long been noticed that the appearance of Stromboli and Vesuvius is markedly dependent upon weather condition, and Brun in a later portion of his book alludes to this phenomenon, accounting for it by postulating a condensation of atmospheric water on hygroscopic salts contained in the anhydrous fumes. A critic may well ask: if the salts in the fumes can on occasion condense atmospheric water, can they not also be relied upon to condense and retain the magmatic water with which, according to orthodox opinion, they are closely associated? It seems wise, then, not to rely too far upon the insolubility of the great white cloud as seen from a distance. Brun's researches carried out actually within the cloud at Kilauea are therefore all the more welcome, but before we can deal with these there are other points to notice in regard to Semero and its Javanese companions.

Semero itself was in a paroxysmal phase when visited. The rim bathed in fumes gave rise to no aqueous condensation, although its surface temperature, observed at 7 o'clock in the morning, was only 5° C. The ashes fell perfectly dry. Aqueous fumaroles were noticed, but they had no deep roots; they occurred at the junction-line of the dry region round about the active foci and the moist plateau region beyond. Their fumes dissolved freely in the air.

Papandajan furnishes a striking instance of the solfataric phase. The crater has a vast undulating floor cut up by stream channels and surrounded by a wall 100 to 300 metres high, breached at the east by the eruption of 1772. The hottest solfatara occur on a little hillock built up of broken pebbles of old lavas much altered; pure opal has frequently been produced at the edge of this hillock.

The solfatara are found to be increasingly hot according as one approaches the centre of the hillock mentioned above. At a distance warm streams and springs occur. At 300 metres from the centre springs at 92° C. were met with, and so on until further advance was precluded owing to hot penetrating acid fumes emitted at a temperature of 270° C.

Leaving out of account the many interesting phenomena connected with the deposition of sulphur, and in the high temperature zone of realgar, we shall restrict our attention to the pressure of the water-vapour in these solfatara. From 92° to 120° C. the vapour pressure of the water mounts rapidly; from 120° to 270° C. it falls no less rapidly. There is no support, therefore, for the common idea that the source of heat is the source of water.

At the time of Brun's visit in 1908 *Tjividey*, another Java volcano, was supplying a diagrammatic vindication of his views regarding solfataric water. A cold stream leapt into the warm central region of the crater, and scattering on the little solfataric plain, emerged steaming and charged with milk of sulphur. Other examples are cited where crater lakes have established themselves, and these too are useful in driving home the argument.

And now for *Kilauea*, the most obliging of volcanoes, paroxysmal and yet not dangerous!

Brun's first experiment consisted in sucking up the fumes from the crater pit through the glass tube system already described. Salts were deposited along the whole length of the tubing, but no trace of moisture.

His second experiment was even more striking. He took a series of dew-point readings within and without the great white cloud as the latter drifted across the rim in a steady stream carried by the prevailing trade-wind; his results, expressed in curves, show in every case a lower dew-point for the air entangled in the cloud than for the normal atmosphere outside. He also collected specimens from the pit itself in vacuum tubes, and, testing them later on in the laboratory, found a like deficit in regard to water. Leaving the rim of the pit he next visited one of the peripheral aqueous fumaroles, situated, as at Semero, where the volcanic heat travelling outwards meets the general pluvial moisture of the mountain mass. Here he obtained, as was to be expected, exactly the reverse result, to wit, a markedly elevated dew-point.

The lowering of the dew-point in the great white cloud of Kilauea is an observation which cannot long go untested. Meanwhile it is difficult to see how a mistake can have crept in to vitiate a whole series of experiments. Brun naturally interprets his result as a further proof of the anhydricity of volcanic emanations; the lowered dew-point is the result of dilution of the air with anhydrous gases carrying hygroscopic solids in suspension.

One last observation regarding the great white cloud of Kilauea may be recorded alike on account of its beauty and its quaintness. A photograph is published showing the author's shadow thrown by strong sunlight on to the cloud, and he assures us that, when he took this photograph, there was no encircling halo round the image of his head. Obviously, then, Brun is not yet numbered among the Saints of Science, and equally obviously the cloud did not consist of drops of water!

Brun now summarizes his results regarding the part played by water in volcanic action, and states them as *Laws*.

To quote these laws would involve too much repetition, but we may note his observations regarding the *volatile constituents of dead rocks*. These latter, heated *in vacuo*, frequently yield large quantities of water accompanied by oxides of carbon, free hydrogen, and subordinate nitrogen. The dead rocks differ from the active rocks both in the abundance of water and hydrogen which they liberate, and also, apparently, in their failure to produce volatile chlorine compounds ($Na\,Cl$, $K\,Cl$, $N\,H_4\,Cl$, $H\,Cl$, etc.) and free chlorine.

We now come to the general *conclusions*, and a sketch is given of the manner in which in nature the emanation is often separated into various fractions, owing sometimes to condensation and sometimes to solution. At a late stage in the history of a volcano secondary emanations resulting from slow oxidation may still be important.

The primary exhalation is not necessarily violent, eruptive, and tumultuous, as one might imagine from hearing so much about paroxyms; an obsidian can crystallize, with concomitant emission of volatile constituents, very slowly and tranquilly, if only it be maintained at a suitable temperature for a sufficient length of time. Take, for instance, Lipari obsidian with 75·4 per cent. silica and an explosion temperature of 830°–902° C. It crystallizes at 523°–530° C. in radiating spherulites which gradually transform the whole mass. It is even possible to follow the change with the microscope. Carbon is expelled and localized between the spherulites; gas is given off; salts, which in the colloid were masked and insoluble in water, now concentrate and become soluble. All the substances are rejected through the crystallization of the silicates; but though rejected with the rest the salts probably play an essential rôle, as catalytic agents, in bringing about the crystallization. In support of this contention Brun points out that he has found no difficulty in obtaining *quartz* by heating amorphous silica with anhydrous chlorides.

And now the dethronement of water seems well nigh complete, but the *micas of the granites* still remain; they remind Brun of the old regime, and accordingly their heads are in danger; he remarks that the crystallization of granite must occur at a temperature very close to the destruction temperature of the micas, and adds that probably the formation of these micas takes place *a posteriori* through hydration. If by *a posteriori* he means to infer that the micas of granites are secondary in the ordinary sense of the term, then, with a vengeance, this is new wine for the new bottles, and of a brand that will find little favour with sober scientists. But if, as is more probable, he merely suggests a hydration of the magma from outside sources during crystallization, he has evidently raised a debatable point. It does not, however, seem obvious that outside help is necessary to account for the presence of the micas, or even of the water so often recorded from cavities in granitic quartz. According to Brun himself the volcanic exhalation contains abundant hydrogen (as $N\,H_3$, $H\,Cl$, etc.) and abundant oxygen (as CO_2, SO_2, etc.). All that seems necessary, therefore, is to suppose that, when sufficient pressure is brought to bear upon them, these two elements no longer shun one another but enter into compounds in association. There is much in this suggestion which would fall into line with a criticism offered by Gautier in 1907, and, as bearing indirectly upon the same question, one cannot forget the interesting results obtained by Barus regarding "Hot Water and Soft Glass in their Thermodynamic Relations" (*Amer. Jour. Sci.*, 1900, p. 161). Perhaps Brun may be persuaded some day to extend his experimental researches into this untrodden field. But all this, and much more besides, merely arises out of the book, it is not the book itself. The point which has been established, so far as can be judged at this distance from the seat of inquiry, is the anhydricity of volcanic exhalations. With the conviction of the truth of his discovery full upon him, it is not surprising to find Brun quoting Scrope's words written in 1825—

"I conceive that no more effectual service can be rendered to science than the destruction of any one of those glaring errors which, apparently based upon a few specious facts, and backed by the authority of some great name, are received by the world in general without examination, notwithstanding that they contradict the ordinary march of nature, and consequently throw the extremest perplexity into that of science."

Those interested in volcanoes should consult the book for themselves. It is to be devoutly hoped that before long its results will be critically tested in the field. Considering the peculiar facilities offered by Kilauea it is perhaps not too much to expect that American scientists will soon take up the challenge and decide the issue once and for all.

E. B. Bailey.

II.—The Building of the British Isles, being a History of the Construction and Geographical Evolution of the British Isles. By A. J. Jukes-Browne, B.A., F.R.S., F.G.S. Third edition, rewritten and enlarged. pp. xv + 470, 80 maps and figures. London: E. Stanford, 1911. Price 12*s*.

During the eighteen years that have elapsed since the publication of the second edition of Mr. Jukes-Browne's *Building of the British Isles*, the records of their construction have increased so greatly that the author has found it necessary to rewrite the whole work. New material accumulates so rapidly that even since the publication of this edition further important changes have become necessary. Thus in the account of the Archean rocks Mr. Jukes-Browne holds that "there is little doubt" that the Moine Gneiss is in part altered Torridon Sandstone; whereas, to quote one opinion on the other side, the recent memoir on Glenelg shows that this conclusion is not accepted by the Geological Survey of Scotland. Mr. Jukes-Browne has made a most thorough study of the English literature, and he interprets it with stimulating originality, independence of judgment, and admirable fairness; thus, where the evidence tells against his former conclusions he candidly admits the fact (e.g., p. 341).

The feature of the book which first strikes attention is the increased weight now attached to the evidence of the petrology of the sedimentary rocks. The importance of palæontology in the interpretation of physical geology has relatively declined. The stratigraphical correlation, on which the whole discussion rests, is no doubt ultimately dependent on the evidence of the fossils; but the lithological evidence is recognized as of increasing value and reliability. It is therefore natural to find that Mr. Jukes-Browne makes frequent reference to the luminous suggestions of the late J. G. Goodchild, a pioneer in this field of inquiry. A large share of space is given to such formations as the Trias, regarding which the lithological evidence is the most instructive. Mr. Jukes-Browne accepts the general conclusions as to the origin of the English Trias of Professor Bonney, who, he remarks (p. 233), "has given so much time and attention to a study of the Bunter deposits, and has such an intimate knowledge of the rocks concerned in the question, that no one is more likely to have arrived at correct conclusions on the subject."

The book consists of a brief introduction on general principles and of fifteen chapters, most of which deal with one geological period each. These chapters usually consist of a concise statement of the stratigraphical evidence, and a discussion of its indications as to the physical geography of each period. The results are illustrated by a sketch-map and sections.

It is impossible to refer to all the interesting, novel, and controversial questions with which the book deals, for it ranges from the genesis of Archean gneisses to that of Boulder-clay; it considers how far the distribution of living Radiolaria gives reliable guidance of bathymetric conditions in Palæozoic times, and it has to deal with scraps of tectonic evidence which are capable of alternative or perhaps of several explanations. The sections on the Scottish pre-Cambrian and Cambrian rocks are the least satisfactory in the book; the chapter on the former shows the increasing weight attached to the formation of gneisses by absorption rather than by pressure alone. The author calls attention to the increase in the known range of the British Cambrians by their identification from bores in Suffolk; but the announcement of Mr. Campbell's discovery of Cambrian near Stonehaven, and the restoration of the Durness Limestones to the Ordovician, which involves a radical change in British Cambrian geography, came too late for insertion.

In the account of the Devonian System the author makes a useful protest against the too frequent description of coral-bearing limestones as coral reefs. He points out that some of the Devonian limestones thus described are crinoid limestones, and their identification as coral reefs can only be regarded as a mistake. He, however, appears to doubt whether any British Palæozoic limestones should be called coral reefs. From my recollections of some Devonian Stromatoporoid limestones, I have never hitherto hesitated to affirm the existence of coral reefs in English Devonian seas. The author quotes Goodchild's refusal to accept any of the coralliferous limestones in the Carboniferous beds to the south of the Lake District as coral reefs. With a party of Glasgow geologists I visited one of the localities on the Solway last summer in consequence of a vigorous discussion on this question, and in comparison with various living coral reefs I felt bound to regard the limestones there as entitled to the name of fossil coral reefs. The question is no doubt largely a matter of definition, and Mr. Jukes-Browne's definition of a coral reef seems too exacting. The question is important, as Palæozoic reef-building corals like those of modern seas seem to have been limited to warm and shallow waters.

The chapter on the Old Red Sandstone gives a judicious summary of the various theories of its formation. Mr. Jukes-Browne now accepts the evidence of an actual land barrier along the Bristol Channel, which separated the Old Red Sandstone lake of South Wales from the Devonian Sea. He does not refer to recent arguments in favour of the marine origin of the Scottish Old Red Sandstone, and his most important proposals in this chapter are the reduction in number of the lakes proposed by Sir A. Geikie. It seems to the writer, however, that this is a step in the wrong direction, as the subdivision of the lakes is really required. The deposits are different from those of large lakes; and at least for some areas the most satisfactory explanation of the Old Red Sandstone seems to be that it was formed as widespread sheets of gravel and sand on the flood plains of shallow, inconstant rivers. These rivers would doubtless have widened here and there into lakes; and when they were cut off from the rivers and their waters evaporated, all their fish would have been deposited in a crowded fish bed. The abundance in some layers of pebbles with wind-worn shapes indicates the exposure of the shingle to sand erosion while lying on the stony flats.

The author maintains the view that the Chalk was deposited in a deeper sea than some recent authors have allowed it, and for at least some zones of the Chalk Mr. Jukes-Browne's conclusions seem most probable.

In his account of the glacial deposits the author calls attention to the fact that the word 'kame' is the Scottish for an esker. That question of nomenclature will have to be considered and settled. The term kame has been largely adopted abroad with quite a different meaning, so that the Scottish kames are not kames according to the foreign acceptance of the term. The greatest convenience of the greatest number would be secured by accepting kame for fluvio-glacial hummocks, although that course may be etymologically and historically incorrect.

The results of the author's study of the succession of English earth movements have a useful bearing on many questions of wide general interest. Thus he has recognized movements in the Midlands which have greatly affected the growth of our present river system. He dismisses Professor Davis' views, without much discussion, except on special points, as when upholding the greater influence of marine as compared with subaerial denudation in planing off the top of the Wealden anticline. Mr. Jukes-Browne recognizes that the rivers of South-Eastern England must once have arisen in the Welsh highlands, as the uplift of the whole British area at the end of the Cretaceous doubtless formed a series of consequential rivers, which flowed across Britain from the western uplands to the North Sea. So far all British geologists agree with Professor Davis, whose paper discussing the relics of that primitive arrangement of our rivers must be regarded as a most important contribution to British geographical evolution. The chief difference of opinion is as to the date at which this system was destroyed. Mr. Jukes-Browne regards the Severn as a very ancient valley, whereas according to Professor Davis it is relatively modern. The plan of the existing rivers of Central and Southern England seems to result from a radial drainage from the Midlands. I called attention to some evidence in favour of this view in a paper on the Evolution of the Thames published in 1894; but that paper was incomplete, as it offered no explanation and cited no other evidence for the hypothetical central plateau, which the radial arrangement of the rivers seemed to indicate as having existed in Lower Cainozoic times. An area of highland might have been left there, owing to the more rapid subsidence of the land to the east and south; the Midlands might have been supported by the same ridge that had earlier caused the difference between the north-eastern and south-western types of the Lower Oolites. But for that supposition I knew of no direct evidence. Dr. Strahan and Mr. Jukes-Browne have now established an uplift of this area which would have served as the original feeding-ground of a radial system of rivers; these authors differ somewhat as to the date of the uplift, Dr. Strahan regarding it as Miocene and Mr. Jukes-Browne as Eocene. According to the latter view the Severn would be a very ancient river, and much older than the Thames.

In connexion with this question it is interesting to note the author's view regarding peneplanes, a spelling which he accepts as the more correct form of the word. He emphatically dissents from Professor Davis' view that peneplanes are due to subaerial action; he remarks that this "may be a theoretical possibility, but I think it has very seldom, if ever, been accomplished" (p. 425). That some peneplanes may be remnants of plains of marine denudation is quite probable; but it seems to be generally admitted that the formation of peneplanes by the combined action of river and wind is one of the most widespread of geographical processes.

In a book of so wide a scope and dealing with so scattered a literature there must be omissions and points where opinions differ. Thus, the statement (p. 454) that marine mollusca do not occur above the height of 500 feet in the Scottish glacial deposits shows that the author has overlooked Smith's excellent memoir on the Ayrshire drifts; the terms Bryozoa and Polyzoa are used indiscriminately (e.g. pp. 321–4). The author occasionally refers (as on p. 360) to dykes as lava-filled fissures, a practice which was once common among miners, but which they have fortunately learnt to avoid.

The author is conservative in the classification of some systems, such as the Silurian; and where he is less so it would have been useful if he had given some explanation or reference when he adopts a well-known term in a special sense, as in the use of Cenomanian for the Lower Chalk. Mr. Jukes-Browne is severe on the retention of such names as Lower and Upper Greensand and Gault; he says no one can defend the retention of the first "awkward and inaccurate appellation" (p. 294). The use of names for series based on the typical localities is no doubt preferable for international correlation; but the old terms are of historic interest and they are often more easily remembered than terms based on unfamiliar place-names. Lower Greensand is no more misleading than Coralline Crag, Torridon Sandstone, New Red Sandstone, and other names which are retained.

Such points are, however, mere details, and one closes the book grateful to the author for this masterly summary of the former geography of the British area and confident that his work will stimulate fresh researches and serve as a platform upon which they can be safely based.

J. W. G.

III.—Le Genre *Caninia*. Par Achille Salée, D.Sc., Directeur de Institut Géologique de l'Université, Louvain. 4to; pp. 62, 9 plates. Bruxelles, 1910.

ONE is scarcely justified in saying that the pioneers of palæontology, when establishing their genera and species, recked little of the morrow. The field was vast and there was much to do; yet they would surely be amazed to see how much labour has to be expended nowadays in order to verify their work.

A good example is seen in the monograph under notice, which is mainly concerned with the revision of two important species, *Caninia cylindrica* and *C. patula*. Most of the letterpress, and seven out of the nine quarto plates, are devoted to this object, and during the course of the work over five hundred sections have been made. It is a pleasure to find that the somewhat drastic revision of the genotype, which appeared in the pages of this Magazine[1] three years ago, is accepted in its entirety.

The value of the work is enhanced by the attention paid to the stratigraphical distribution of the material. An outline of Dr. Vaughan's zonal scheme appears in the Introduction, and the author throughout keeps in touch with the progress of zonal work in these Islands and in Belgium; discussing the scope of the monograph, he says that "il ne doit servir . . . que d'introduction à une étude detaillée de paléontologie stratigraphique sur le Calcaire carbonifère de la Belgique".

Caninia cylindrica was first described, from somewhat fragmentary material, by M'Coy in 1843 (*Siphonophyllia cylindrica*).[2] In the same year Michelin described a similar fossil as *Caninia gigantea*, his figured specimen coming from Tournai.

M. Salée has examined a cast of M'Coy's type, but apparently has not been able to procure topotypes to work on. Nevertheless he feels justified in identifying *Caninia cylindrica* amongst material from

[1] R. G. Carruthers, "Revision of some Carboniferous Corals": Geol. Mag., April, 1908, pp. 158–71, Pl. VI.

[2] His type is preserved in the Griffith Collection at Dublin, the locality being given as "Arenaceous limestone, Ardsallagh, Drumguin".

Tournai, which he has used as a basis for his revision. The accompanying plates are first-rate, the suite of five serial sections being very satisfactory. Sound reasons are given for regarding de Koninck's *Zaphrentis herculina* as a variety of M'Coy's species, as here understood.

Michelin's *Caninia patula* is revised from topotypes, and is treated very fully. On pls. vi–viii, there are five sets of serial sections, in one of which ten sections are figured (this specimen actually yielded forty sections). In addition two vertical sections are given, so that one obtains a very complete idea of M. Salée's conception of the species. In this case there can be no hesitation in accepting the revision. Michelin's type is preserved in the Musée d'Histoire Naturelle at Paris, where it had lain unrecognized for many years; in my experience, topotypes which are externally identical with this specimen give sections that agree entirely with M. Salée's figures and description.

Important additions are made to the synonymy of the three species, and two new varieties, *densa* and *vesicularis*, are associated with *Caninia patula* and *C. cornucopiæ* respectively.

The monograph closes with some remarks on the phylogeny of the genus, of which the ancestor is taken to be a *Zaphrentis* and the descendant a *Cyathophyllum*. Such an idea can only be regarded as tentative. It must be admitted that none of the species of *Caninia* can be shown to have descended from any Carboniferous species of *Zaphrentis* yet known. M. Salée justly considers that *Cyathophyllum* must be regarded as a polyphyletic genus, although it is very probable that it will eventually be possible to demonstrate that some of the Visean species were derived from *Caninia patula*.

The weak spot of the revision lies in the question of nomenclature between *Caninia cylindrica* and *C. gigantea*. If it can be said that Michelin's type is lost and that similar material from Tournai varies too much to be used as a basis for redescription, while topotypes of M'Coy's species are constant in character and agree with M. Salée's account of his Tournai material, then the revision can be accepted as a most satisfactory piece of work. But in the meantime the question remains an open one.

There are many interesting observations on ontogeny, and the mode of development of dissepiments is noted with care; some contribution is also made towards the solution of the very puzzling problem arising from the deposit of stereoplasma round the septa of many Palæozoic corals, especially in those of the *Caninia* group. The septa, which are of necessity bilamellar in all Anthozoa, are, however, erroneously considered to be unilamellar.

Typographical errors are chiefly apparent in the Bibliography.

These facts apart, the work is of much value. The lavish illustrations, mostly from serial sections, are especially useful in bringing out the specific constants in fossils of so variable a nature, and it is to be hoped that M. Salée will be enabled to continue his work on similar lines.

R. G. C.

IV.—British and Foreign Building Stones. A Descriptive Catalogue of the Specimens in the Sedgwick Museum, Cambridge. By John Watson. 8vo; pp. viii, 483. Cambridge: at the University Press, 1911. Price 3*s.* net.

THAT the practical applications of Science are receiving more and more attention at our Universities is a matter well known and of supreme importance. Nevertheless, the work before us comes to a certain extent as a surprise in showing what a very fine collection of building-stones has been gathered together from all parts of the world and arranged in the Sedgwick Museum. Great credit is thus due to Professor Hughes and those who are associated with him in teaching stratigraphical geology and petrology, as well as to Mr. John Watson, who has written the account of the specimens with evident care and after much painstaking research.

In his Introduction the author gives a general account of building-stones, with remarks on the value of different tests, on the qualities of stone adapted for various purposes, and in different regions and situations, on seasoning, and on the causes of decay. Then follow descriptions of the Igneous, Metamorphic, and Sedimentary rocks of all parts of the world, accounts of the quarries and the working of stone, historic and practical, with references to ancient monuments and to buildings of different ages where particular stones have been used. This portion of the work occupies about one-half of the volume, and it contains a large amount of interesting as well as useful information.

The remaining portion of the volume consists of the particular description of the rock-specimens, which number 1,126. They are arranged under (1) British, and (2) Colonial and Foreign, in each case under the headings of Igneous, Metamorphic, and Sedimentary. The following particulars are given so far as possible, but there are naturally many omissions, and the ages of Igneous rocks are not noted: Name (commercial or otherwise) of stone; Geological age (of Sedimentary rocks); Characters of rock-specimen, and if admitting of polish; Locality; Donor or Collector; Chemical composition; Weight per cubic foot; Specific gravity; Ratio of Absorption or Porosity; and Crushing strain.

The specimens are mostly 4½ inch cubes, with one face polished when suitable, one left rough, and the others dressed in the style generally adopted in the locality where the stone is worked.

It is to be noted that the petrological designations on the labels of the igneous rocks have been contributed by Mr. A. Harker, who has thus imparted a special value to this part of the book.

Roofing-slates, paving-stone, road-metal, and marble, examples of which are arranged in the Sedgwick Museum, do not come within the province of the work; but some flags and ornamental stones are naturally described under the building materials, such as Caithness Flagstone, Torquay Limestone, Hopton Wood Stone, and Larvikite (one of the Norwegian granites).

Although Mr. Watson remarks that the collection is "very far from being exhaustive", it is a capital representative series. No

British pre-Cambrian sedimentary rocks are included, but Torridon Sandstone might be added; and towards the other end of the geological scale there is a noteworthy omission of any reference to Greywether sandstone, while mention might have been made of Coralline Crag, which has yielded building-stone, and of British tufa, which, as at Dursley in Gloucestershire, has also been used for building purposes. It should be noted that the Bargate Stone (pp. 196, 317) is Lower (not Upper) Greensand; the "Bastard Freestone" of Shepton Mallet (p. 304) is Lower (not Upper) Lias; while on p. 165 Seaton should be Keinton Mandeville.

V.—The Movements of the Subsoil Water in Upper Egypt.

THIS subject is dealt with by Mr. H. T. Ferrar (Ministry of Finance, Egypt, Survey Department Paper No. 19, 1911). As he remarks, the effects of perennial irrigation in raising the level of the subsoil water, and its influence on health, and on crop-production, owing to the concentration near the surface of injurious salts, are matters of considerable importance. In studying the region the author finds it convenient to describe the wells and other hydrological subjects under the headings of *riverain*, *basin*, and *desert*: areas which form zones parallel to the Nile. Thus, "regarded broadly, the water-table in Upper Egypt behaves as a horizontal plane with flexible edges, which moves up and down as if actuated by an annual tide. The inner flexible edge, which is about one kilometre wide, is the riverain zone. This moves in the manner anticipated, namely, as a plane surface hinged along the side away from the river; but, instead of the hinged edge being on the desert edge, it rises and falls with the rise and fall of the water-plane beneath the basins. The basin zone, or horizontal part of the water-plane, moves up and down almost horizontally, and has an area not greatly less than the area of Upper Egypt which is cultivated. The outer flexible or desert edge of the water-plane, which we will call the desert zone, also moves up and down almost horizontally, but the range of its movement is considerably less than the range of movement of the basin zone."

The work, so far, has shown that consecutive observations extending over a number of years are necessary to complete the knowledge of the movement of the subsoil water. Experiments at present indicate that "In our so-called riverain zone, the water moves at the rate of 150 metres per day at one period of the year, and at other seasons, namely, when the water-table is stationary, it is practically stagnant. The water in the basin zone would seem to have a velocity of less than two metres per day, and that of the desert zone a still lower velocity". Furthermore, "Geological considerations have shown that the subsoil water mingles with the water of the Nile at all times of the year, and that interchange of Nile water and subsoil water takes place continually. In addition to the modifications introduced by geological structure, it has been found that artificial constructions have an influence upon the underflow, and that a quantity of water passes beneath and round the ends of barrages."

VI.—New Zealand Geology.

New Zealand Geological Survey.—In Bulletin No. 10 (New Series), 1910, Mr. Colin Fraser describes "The Geology of the Thames Subdivision, Hauraki, Auckland". The area forms part of the promontory of the North Island east of Auckland and south of Coromandel, and it includes Waihou on the south and Hastings on the north. The prevailing rocks of the area are Tertiary andesites and rhyolites, and they indicate three periods of volcanic activity, referred (with doubt) to Upper Eocene, Miocene, and Pliocene. These rocks form the hilly and mountainous ground of Hastings and the country east and south-east of Thames Town. The mountains, which form a part of the Cape Colville range, rise to elevations of 2,000 feet and more; indeed, Table Mountain, formed of a dyke of andesite, is reckoned to be about 2,800 feet above sea-level. The volcanic accumulations rest on an eroded floor of Jurassic and older sediments, which are exposed only in the northern portion of the area on and near the coast of the Firth of Thames. The pre-Jurassic strata have yielded no fossils, and the Manaia Hill Series, referred to Upper Jurassic, has yielded only *Inoceramus haasti* and *Belemnites*.

The southern portion of the area consists for the most part of the broad flood-plains of the Rivers Thames (or Waihou) and Piako, with raised sea-beaches and high-level river-terraces. Volcanic activity ceased about the close of the Pliocene period, and after the later earth-movements there has been much infilling of the bays by fluviatile agencies.

Special attention is directed to the Thames goldfield on the borders of Thames Town. There gold-silver quartz veins with ore-shoots are worked in the andesitic and dacitic rocks of the earliest Tertiary volcanic period. These quartz veins also penetrate the Jurassic and pre-Jurassic sediments, but this floor of older rocks is more than 1,000 feet below sea-level at the Thames goldfield. In the opinion of the author (pp. 3, 45) most of the ore-shoots "appear to show a considerable dependence on depth below the existing land-surface, since, irrespective of the elevations of the outcrops of the veins, the upper zone, extending to a depth of from 400 to 500 feet, has proved much the more productive . . . 500 feet has proved a critical depth on this field . . . The downward limit of the pay-ores mined appears, therefore, to conform roughly to surface-contours". He considers "that the principal veins at the Town of Thames occur in the near vicinity of the vent of an ancient volcano". Very little gold has been obtained from creek gravels, for, as the author remarks, while there has been much denudation of the ore-bearing veins, "most of this auriferous rock-waste was discharged by the streams on to an old foreshore now depressed hundreds of feet below sea-level, and overlain by recent alluvium."

Auriferous tellurides occur in a few localities. The author draws attention also to the widespread alteration of the volcanic rocks by hydrothermal action. The work is well illustrated with maps and sections, mining plans, and pictorial views.

VII.—Brief Notices.

Pre-Cambrian Rocks of Alberta, Canada.—Mr. C. D. Walcott has described a series of unaltered sedimentary strata, consisting of shales and sandstones grouped, as the Hector and Corral Creek Series, which lie unconformably beneath the Cambrian rocks in the Bow River Valley, Alberta. These pre-Cambrian rocks have not at present yielded any fossils. (Smithsonian Misc. Coll., liii, No. 7, 1910.)

Cambrian Fauna of North America.—Mr. Walcott calls attention to the "Abrupt Appearance of the Cambrian Fauna" (op. cit., lvii, No. 1, 1910). He remarks that "The evidence afforded by the few traces of pre-Cambrian fossils is inconclusive as far as determining whether their habitat was in marine, brackish, or fresh water"; but he adds that life was probably first developed in the open ocean, as advocated by Mr. W. K. Brooks, and that it became adapted to littoral and shore conditions in Algonkian time. The apparently abrupt appearance of the Lower Cambrian fauna is to be explained by the absence on the present American land areas of the sediments and organic remains belonging to the period between the formation of the Algonkian continents and the earliest encroachment of the Lower Cambrian sea. To this intermediate era Mr. Walcott applies the name Lipalian.

Iowa Geological Survey.—The Annual Report for 1909 (1910) of the State Geologist, Dr. Samuel Calvin,[1] is accompanied by reports on the geology of ten counties in Iowa by Messrs. M. F. Arey, T. H. Macbride, B. Shimek, and S. W. Stookey. The rocks described include Devonian, Carboniferous (Mississippian and Pennsylvanian), Pleistocene (Nebraskan, Aftonian, Kansan, Iowan, etc.), and Recent. The mammalian remains from the Aftonian Interglacial deposits include *Mylodon*, *Mastodon*, *Elephas*, *Equus*, etc.; those from the Alluvial deposits include Bison, Elk, etc. The origin of the loess is briefly discussed, and the view is supported that it is essentially æolian. Much valuable information is given on the economic branches of geology—on coal, building-stones, brick-clays, soils and forests, drainage and water-supply.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

1. *April* 26, 1911.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., Vice-President, in the Chair.

The President made the following announcement:—

"By the decease of Professor Thomas Rupert Jones, F.R.S., in his 92nd year, the Geological Society has lost one of its oldest and most valued members, who was formerly (1850–62) Assistant Secretary of the Society, and Editor of the Quarterly Journal. During his long life Professor Rupert Jones was an ardent geologist and palæontologist, and has left behind him in the Palæontographical Society's memoirs, in the Quarterly Journal of the Geological Society, in the Geological Magazine, and in the Annals of Natural History, no mean record of his abilities and strenuous labours. Nor was his work confined to original papers, but as Editor of the Quarterly

[1] Since this notice was written we regret to learn of the death of Dr. Calvin.

Journal of the Geological Society, the GEOLOGICAL MAGAZINE, the *Reliquiæ Aquitanicæ*, Dixon's *Geology of Sussex*, the *Arctic Manual*, and other works, he showed a high-class capacity in literature.

"Never in receipt of more than a very moderate income, derived from a small pension upon his retirement from the post of Professor of Geology in the Royal Military College, Sandhurst, he was unable to make any suitable provision for his death (when his pension ceased), and has left a widow with two daughters and an invalid son, almost wholly unprovided for.

"It is proposed to form a Committee of Geologists to consider the means of providing some memorial in aid of the widow and daughters of the late Professor. Any Fellows present willing to assist in this object are requested to communicate with the Assistant Secretary."

The following communications were read:—

1. "The Llandovery and Associated Rocks of North-Eastern Montgomeryshire." By Arthur Wade, B.Sc., F.G.S.

The area dealt with in this paper is in the neighbourhood of Welshpool. It comprises part of the Severn Valley and the whole of the Vale of Guilsfield. A summary of the work done is first given, and the deficiencies of the present geological map are pointed out.

The detailed sequence is as follows:—

SALOPIAN (1,000 feet)	Ludlow	Yr Allt Group	3. Sandy flags and shales, sometimes calcareous.
			2. Hard thick flags, with thin shale-bands and septaria.
			1. Thin muddy shales.
	Wenlock	B. Western facies	Blue flags, gritty, with calcareous concretions or boulders.
		A. Eastern facies	Blue flags, as a rule minutely false-bedded, with earthy mudstones, and a thin limestone bed.
VALENTIAN (700 feet)	Buttington Group (= Tarannon Shales)		Green and purple barren shales.
	Upper Llandovery	B. Western facies (Cloddiau Group)	2. Thick calcareous flags and mudstones.
			1. Blue shales.
		A. Eastern facies (Cefn Group)	Thick calcareous flags, with *Pentamerus* Limestone.
	Lower Llandovery	PowisCastle Group	Red sandstone and conglomerate, with occasional limestone developments.
ASHGILLIAN (50 feet)	Gwern-y-Brain Beds		Black shivery shales, phosphatic with a band of black crystalline limestone near the base (= *Staurocephalus* Limestone?).
CARADOCIAN (1,300 feet)	Gaer-fawr Group		3. Calcareous mudstones and limestones (= Bala Limestone); coarse, ashy, felspathic bands. Thin, phosphatic, pale-grey shales at the base.
			2. Massive grits, with bastard limestones.
			1. Flags and grits, with some shale-bands.
	Pwll-y-Glo Group		Shales and flags, with some grit-bands.
GLENKILN-HARTFELL (= *Dicranograptus* Shales)	Trilobite Dingle Group		2. Nodular mudstones and grey shales, with *Trinucleus*.
			1. Splintery grey shales, with *Diplograptus* (*Mesograptus*) *foliaceus*, etc.

In the detailed succession now worked out, the Ashgillian and the Valentian are for the first time distinguished, while the distinction between the Wenlock and the Ludlow Beds is brought out by means of graptolite zones.

The stratigraphical succession is shown by traverses; but, owing to successive overlap of the upper beds, no single traverse gives the full succession. The different groups are traced over the area mapped, and the chief fossiliferous exposures described, with full lists of the fossils obtained. The district is shown to be transitional in character between neighbouring districts on almost every side, combining many of their features.

The structure of the area is mainly that of an anticline with 'keystone' faulting, the dominant features being determined by the intrusive masses of the Breidden Hills and the small Standard Dyke of Welshpool. The two boundary faults of the arch have very considerable downthrows.

A brief account is given of the Welshpool Dyke, with chemical analyses of the rocks.

The glacial geology of the area is also described, three series of deposits being observed: (1) a high-level series, (2) a low-level series, and (3) a stratified series. The Guilsfield Valley is shown to have been occupied by a glacial lake, and the reversed drainage of the Cefn-Yspn Brook is shown to be connected with a 'col' through which the overflow water drained.

A short description of some of the fossils, including one or two new species, is given, and the paper is supplemented by correlation tables and maps.

2. Dr. J. D. Falconer, M.A., F.G.S., then gave an account of the Geology of Northern Nigeria, illustrating his remarks by means of lantern-slides. He pointed out that the Protectorate of Northern Nigeria covers an area of about 255,000 square miles, over half of which crystalline rocks are exposed at the surface. A series of hard banded gneisses of an Archæan type is intermingled with a series of quartzites, phyllites, schists, and gneisses of sedimentary origin, in such a way as to suggest that the two series, while originally unconformable, have been at a later period affected by a common folding and foliation along axes which are predominantly meridional in direction. The two series have also been pierced by numerous igneous intrusions of a granitic type, which are subdivided into (1) an older, wholly or partly foliated group, and (2) a younger, non-foliated group, characterized by the predominance of soda-bearing types.

Folded and faulted rocks of Cretaceous age are found in the valleys of the Benue and the Gongola. They consist of a lower series of sandstones and grits, in places salt-bearing, and an upper series of limestones and shales with numerous fossils of Turonian age. These Cretaceous rocks are overlain unconformably by a horizontal series of sandstones, grits, conglomerates, and ironstones, which in Sokoto province contains intercalations of Middle Eocene limestones. Considerable volcanic activity occurred during Tertiary times, and gave rise to extensive fields of basaltic lava in Bauchi and Bornu, as also to numerous puys of trachyte, phonolite, olivine-basalt, and nepheline-basalt throughout Southern Bauchi, Muri, and Yola. Repeated minor oscillations of the crust occurred during the latter part of the Tertiary era, and culminated in the elevation of the Bauchi plateau, the depression of the Chad area, and the establishment of the present river-system.

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2. *May* 10, 1911.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Lower Carboniferous Succession in the North-West of England." By Professor E. J. Garwood, M.A., Sec.G.S.

The area dealt with includes the whole of Westmorland north and west of the Dent Fault, together with North Lancashire to the north of the Lune Valley, and the extreme northern corner of Yorkshire, to the west of Middleton in Teesdale, is also included.

The following general succession has been established:—

	Zones.	*Sub-zones.*	*Bands.*	*Probable Bristol Equivalents.*
BEDS with *Lithostrotion.*	*Dibunophyllum.*	Upper (?)	Botany Beds.	D_3
		Middle: *Productus latissimus.* *Lonsdalia floriformis.*	*Saccammina.* *Girvanella.*	D_2
		Lower: *Cyathophyllum Murchisoni.*	*Cyrtina septosa.* *Daviesiella llangollensis.*	D_1
	Productus corrugato-hemisphericus. *Spiriferina laminosa.*	Upper: *Nematophyllum minus* *Cyrtina carbonaria.*	Bryozoa Bed.	S_2
		Lower: Gastropod Beds.	*Clisiophyllum Keyserlingi.*	S_1
BEDS without *Lithostrotion.*	*Michelinia megastoma.*	Upper: *Daviesiella carinata.*	*Spirifer* cf. *furcatus.*	C_2
		Lower: *Camarophoria isorhyncha.*	*Thysanophyllum pseudo-vermiculare.*	C_1
	Athyris glabristria.	Upper: *Seminula gregaria.*	*Rhynchonella triplicata.* *Productus globosus.*	•
		Lower: *Solenopora.*	*Eumetria proava.* *Pleurodictyum cleistoporoides.*	γ Z_2?
	Basement Conglomerate.			
	Spirifer pinskeyensis Beds.			

The value of the different zonal indices selected is discussed and their distribution over the area is described. It is shown that, whereas the zonal indices chosen for the larger groups of beds are often sporadically distributed in the zone, the bands form remarkably reliable horizons, extending frequently over large areas.

The rocks are described under the following districts:—

Shap and Ravenstonedale.
Kendal and Kirkby Lonsdale.
Arnside and Carnforth.
Grange and Furness District.
The Westmorland Pennines and Middleton in Teesdale.

For purposes of detailed description, the Shap–Ravenstonedale area is taken as the type, and the other districts are briefly compared with it. It is shown that in no one district is a complete development of all the zones observed, and that it is only by taking a broad survey of the whole area that the detailed faunal sequence can be definitely established.[1] In the Shap area the *Michelinia megastoma* Zone is scarcely represented, while farther west the fauna of this horizon is one of the richest in the whole of the North-Western Province.

The changes in the fauna of certain zones, when traced over large areas, often depend more on the lithological characters of the rocks and their modes of deposition than on the introduction of new forms at definite horizons; thus, certain corals, such as *Zaphrentis enniskilleni*, which is found to be associated with argillaceous deposits, characterize different horizons in different districts.

The deposits are shown to be for the most part of shallow-water origin. The period of great submergence appears to have been during the deposition of the *Nematophyllum minus* Beds and the Lower *Dibunophyllum* Beds.

The lowest deposits are characterized by highly magnesian limestones; these appear to have been deposited under lagoon-like conditions which encouraged the growth of calcareous algæ, especially *Solenopora*, and these in many places contribute largely to the formation of the deposits. The majority of the limestones throughout the series are rich in Foraminifera, and the more shaly layers in Ostracods and Bryozoa.

The silicification of the organisms at many horizons in the sequence is discussed, and the conclusion is arrived at that both silicification and dolomitization of the limestones were practically contemporaneous with the deposits in which they occur. The presence of spotted and 'brecciated' limestones is shown to be characteristic of the upper portion of the Lower *Dibunophyllum* Zone.

The movements which have affected the rocks in the Arnside district have been the result of nearly horizontal thrusts, and it is shown by means of zoning that the beds have, in places, been inverted and are dipping at over 120°.

[1] Thus the lowest zones are practically absent from the Cross Fell area, since the base of the Melmerby Scar Limestones represent an horizon high up in the *Nematophyllum* sub-zone: showing that the complete submergence of this district did not take place until long after that of the area farther to the west.

The palæontological divisions here described are correlated with their probable equivalents in the Bristol area; but no exact comparison has been found possible in the case of the lowest beds, which occur in Pinskey Gill.

In the palæontological portion of the paper several new species of Corals and one new genus are described, and the affinities of several Corals and Brachiopods are discussed.

2. "The Faunal and Lithological Sequence in the Carboniferous Limestone (Avonian) of Burrington Combe, Somerset." By Professor Sidney Hugh Reynolds, M.A., F.G.S., and Arthur Vaughan, M.A., D.Sc., F.G.S.

Lithology.—The series is almost continuously calcareous from the base of Z to D_1, where the section ends; the K beds are, to a large extent, shales. Crinoids are the prevalent limestone-builders throughout K, Z, and C_1; in C_1 the rock is largely of the coarsely crinoidal type known as 'petit granit' by the Belgian geologists.

A band of coarse oolite occurs in the upper part of K_1; but, apart from this, no oolite is met with until the top of C_1 is reached. C_2 and S_1 are very largely oolitic, conspicuous white oolite prevailing at the top of C_2. There is much oolite in the upper part of S_2.

An important point is the prominent part played by Foraminifera, which are the principal limestone-builders in C_2, S_1, and much of S_2. Many of the oolitic limestones are foraminiferal; but especially in C_2 there is much limestone abounding in Foraminifera, though not oolitic.

In the upper part of S_2 peculiar concretionary limestones, showing imperfect 'Cotham Marble' structure, occur; but these are not so prominent as in other parts of the South-Western Province.

The Burrington section agrees with the other sections in the South-Western Province, in showing dolomitization in the upper C_1 beds. A strong development of chert occurs at three levels—S_2, γ, and Z_1.

Palæontology.—The palæontological portion includes notes on several early mutations of well-known Carboniferous gentes, and deals, in detail, with the megastomatid Michelinias and the large Caninias (*C. patula* and *C. cylindrica*). The essential similarity of developmental stages in vesicular structures in widely distinct groups of corals is illustrated in the cases of *Caninia cylindrica* and *Lonsdalia floriformis*.

The early Syringothyroid stage in the Carboniferous 'Spiriferinas', a stage not observable in the Liassic type-species, is described, and the generic designation of *Syringothyris laminosa* is discussed.

A section is devoted to a comparison of the deposits at Burrington Combe with those at other points of the Belgian and South-Western Provinces. The great variability of deposit during the Mid-Avonian period is emphasized, and the rapidity of accumulation of beds of crinoidal debris is compared with the slow growth of dolomitic limestone at that time.

3. *May* 24, 1911.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communication was read :—

"On the Geology of Antigua and other West Indian Islands, with reference to the Physical History of the Caribean Region." By R. J. Lechmere Guppy. (Communicated by Professor E. J. Garwood, M.A., Sec.G.S.)

After noticing the work of former observers on the geology of Antigua, the author gives a brief description of the formations of that island, showing that it is divided into three principal regions—(1) the Volcanic (or Igneous) Region; (2) the Central Plain; and (3) the Calcareous Formation; the first-named being, according to previous authors, the oldest, as it is pre-Tertiary, and the others following in succession. The Calcareous Formation, hitherto considered the newest, contains fossils, of which the most remarkable is a species of *Orbitoides*. After a discussion of these formations, and especially of the evidence for the so-called 'Oligocene' age of the Calcareous Formation, the conclusion is reached that this formation is the oldest, not the youngest, and is probably Eocene or older. The island was raised above sea-level by the development of the great Antillian dislocation, which is described, and divides each of the islands of Guadeloupe and Antigua into two parts, of which the eastern is calcareous and the western volcanic. In Antigua the Central Plain intervenes between the two parts, while in Guadeloupe they are only separated by a narrow channel. In support of this proposition the physical features of Antigua are discussed, and it is shown that the island has not been submerged since the volcanic period.

The position and age of the Scotland Series of Barbados are then discussed, and that series is shown to be Eocene, the lower beds being possibly Cretaceous and being a remnant of the Atlantis Continent.

The extension, age, and position of the *Orbitoides* Bed of Trinidad are next dealt with, and some further remarks are added on the physical history of the Caribean Region.

II.—Zoological Society of London.

May 23, 1911.—Dr. A. Smith Woodward, F.R.S., Vice-President, in the Chair.

1. A paper entitled "Tooth-Germs in the Wallaby (*Macropus billardieri*)" was presented by Dr. A. Hopewell Smith, M.R.C.S., L.R.C.P., and Dr. H. W. Marett Tims, M.A., F.Z.S., F.L.S.

The material upon which their observations were based had been kindly sent to the authors by Mr. Brooke Nicholls, of Melbourne. It consisted of three embryos of *Macropus billardieri*. The smallest specimen (allowing for the difference in size of the adults of different species) was considerably younger than that of any other Diprotodont previously examined. In the upper jaw they had identified six incisors, thus confirming M. F. Woodward's original statement. The functional incisors of the adult appeared to be the second, fourth, and sixth of the series. There were four premolars, of which the first, third, and fourth persisted. There was also one molar tooth.

In the lower jaw, owing to the difficulty of interpreting the conditions, it was not certain whether there were representatives of five or six teeth in front of the premolars. Presuming there were five, the large functional incisor of the adult was the fourth of the series. As in the upper jaw, there were four premolars and one molar, the second premolar not fully developing. There were evidences of vestigial predecessors to the large lower incisor and to pm. 4.

The following points of histological interest were noted:—

(1) The heaping up of the epithelium along the alveolar margins, a character often supposed to be peculiar to the Ungulates.
(2) The precocious development of the enamel.
(3) The compactness of the stellate reticulum of the enamel-organ.
(4) The abundant evidence of blood-vessels within the enamel-organ, thus confirming the observations of Poulton and Howes in the Rodents. The opposite opinion is usually held.
(5) Some slight evidence in support of the fusion of enamel-organs. Such fusion has been recorded in the fishes and reptiles, but not hitherto in mammals.

2. Professor J. P. Hill, D.Sc., communicated a paper by Dr. R. Broom, C.M.Z.S., "On the Structure of the Skull in Cynodont Reptiles." The author, after a study of all the available material contained in the British and South African Museums, gave a detailed comparative account, illustrated by a series of figures, of the morphology of the skull in the chief genera of the Cynodontia, including *Bauria*, *Nythosaurus*, *Cynognathus*, *Trirachodon*, *Gomphognathus*, *Diademodon*, *Sesamodon*, and *Melinodon*. He also discussed in some detail certain peculiarities of the Mammalian skull, apparently derived from a Cynodont ancestor.

3. Dr. C. W. Andrews, F.R.S., F.Z.S., read a paper "On a New Species of *Dinotherium* from British East Africa". The specimens described were sent to the British Museum by Mr. C. W. Hobley, Commissioner of Mines for British East Africa. They included portions of the mandible with teeth, a calcaneum, and a patella of a small species of *Dinotherium* nearly allied to *D. cuvieri*, from the Lower and perhaps Middle Miocene beds of France. The new species, which he proposed to call *Dinotherium hobleyi*, differed from *D. cuvieri* in several particulars—e.g., the inner anterior column of pm. 3 was more distinctly developed, and the talon of m_3 had a distinct tubercle on its inner side. Remains of Rhinoceros, a giant Tortoise, *Trionyx*, and Crocodiles also occurred. The bones were well preserved in a tough clay, and further collecting would no doubt yield important results.

CORRESPONDENCE.

LAND-ICE HYPOTHESIS.

Sir,—In the May number of the Geological Magazine, p. 238, the Rev. Osmond Fisher calls attention to the evidence he has seen of disturbances in the rocks below boulder-clays, and suggests that the subject is one worth investigation. With this view most geologists will agree. Such disturbances not only affect the rocks upon which the boulder-clays rest, but are to be found in all kinds of glacial deposits as well. Roughly speaking they may be classified as follows:—

1. Disturbances caused by tree roots.
2. The creep of the soil down slopes.
3. Vertical arrangement of pebbles near surface of ground.
4. Creep of soil-cap caused by masses of consolidated snow on slopes.
5. Dragging along of all kinds of deposits by glaciers moving over them.
6. Ploughing up of deposits by the snouts of glaciers or by stranded icebergs.

Granting that the contortions so frequently seen may have been formed in the several ways enumerated above would it not be a great step in advance if means could be found whereby the different kinds could be distinguished?

1. Roots of any size seldom penetrate very deep, but they spread out from the tree trunks near the surface for great distances in many cases. Their effect is not to contort the surface beds, but rather to destroy all traces of bedding at or near the surface.

2. Soil creep may be the cause of crumpling the surface layers of the softer rocks. Such movements would form disturbances which may be likened to waves, the crests and hollows of which would have a trend at right angles to the slope of the surface of the ground. The growth of vegetation would tend to prevent such creep, whereas the presence of much snow and frost would tend to make it more marked.

In the case of the binding of the harder sandstones and shales at the surface the only agent competent to produce the effect is either névé or glacier ice.

3. Dr. Strahan has called attention to the remarkable manner in which all kinds of objects on the surface tend to assume a vertical position in Spitzbergen. I have noticed that in the case of a large number of gravels which there is reason to suppose are of Interglacial age, the pebbles near the surface stand on end. It would be interesting to know if the peculiarity to which Dr. Strahan refers is something more than skin deep.

4. In the case of valleys containing snow banks on their sheltered sides, the creep might be of the same nature as 'soil creep' but more pronounced in character.

5. In many of our river valleys there are river gravels which show signs of great disturbance. Such disturbances are never found in the more low-lying deposits. Those disturbances are very marked on large flat areas and could not possibly be the result of 'soil creep'. They consist of plots and undulations the trend of which generally points to motion down the valley and not down the slope into the valley. Very frequently they extend to depths of from 8 to 10 feet, and I have seen them so marked that the gravel has been folded into the Keuper Marl and the marl into the gravel. To my mind the disturbances could not possibly be the result of soil creep or tree roots. Glacial conditions of short duration seem the most likely explanation.

Similar contortions may often be seen in glacial gravels and sands and beneath boulder-clays. Near Spendon, Derbyshire, a mass of Boulder-clay was contorted into the Keuper Marl and masses of marl were enclosed in the Boulder-clay; there were also striated boulders of Mountain Limestone deeply embedded in the red marl.

6. Many of the disturbances in the Chalky Clay seem to have been formed by the direct pressure of the ice front, others as at Cromer by the overriding of the Boulder-clay by the ice.

I agree with the Rev. O. Fisher that the subject is worth investigation, and feel sure that the question of how the disturbances and folds were produced can be ascertained by studying the details of the phenomena. One generally finds the subject dismissed with the remark 'surface creep'.

R. M. DEELEY.

INGLEWOOD, LINGCROFT AVENUE,
HARPENDEN.
May 23, 1911.

GEOLOGY OF PADSTOW AND CAMELFORD.

SIR,—Referring to the letter signed "Reviewer" which appeared in the April number of the GEOLOGICAL MAGAZINE concerning the memoir on the Geology of Padstow and Camelford, I should be obliged if you would allow me to say that I entirely agree with the statements contained therein as to Mr. Ussher's priority in representing on a map the three main divisions of the Devonian Rocks in the area in question, and also to express my regret that no reference was made to this fact in the memoir.

J. J. H. TEALL.

GEOLOGICAL SURVEY OFFICE,
28 JERMYN STREET, S.W.
May 26, 1911.

DREIKANTER.

SIR,—With reference to the discussion in your columns on the use of the word Dreikante, I should like to point out, as I have already done elsewhere, that the term is more appropriately employed for the comparatively common form with three long, nearly parallel edges, than for the rarer type which is roughly tetrahedral and has typically six instead of three edges.

If a stone lies on a sandy tract, the wind may, by means of the sand that it carries with it, bevel the upper portion of the side turned towards it, and at the same time gradually remove the sand beneath till the stone falls, turning over towards the wind on to its abraded surface. A new plane of abrasion will then be formed on the stone, making an angle of about 60° (a crystallographer would call it 120°) with the first, and, under favourable circumstances, by the repetition of the same movement a trigonal prismatic form with three parallel sides and edges will be more and more distinctly developed.

The tetrahedral or 'tripyramidal' form and other more irregular shapes would appear to be due to the stone falling over obliquely instead of directly towards the wind, either on account of its shape or because the sand has been removed unevenly from below it.

If a general expression be required for any wind-shaped stone, we might speak of a 'ventifact', on the analogy of artifact, sometimes spelt 'artefact', which is already in use for an object, such as a palæolith, fashioned by men, and of 'ventiduct', which has been employed in architecture. John W. Evans.

Imperial Institute.
June 7, 1911.

BRITISH PILLOW-LAVAS.

Sir,—The brilliant paper on British pillow-lavas by Messrs. Dewey and Flett in your May and June numbers is an illustration of what may now be done in rational petrology by the collation and interpretation of the great mass of facts accumulated on the descriptive side of the science. The main points brought forward by them, i.e. the existence of the spilitic suite, and the explanation of its association with black shales, limestones, and radiolarian cherts, seem now to be thoroughly established.

One is obliged, however, to dissent from the view (pp. 242, 245) that the spilitic suite is separate and distinct from, and, so to speak, co-ordinate with the Atlantic and Pacific kindreds, as established by Harker, Becke, and Prior. Using these terms merely as convenient names for the two broad chemical divisions in igneous rocks, and disregarding the much-disputed distributional assumptions on which they rest, it seems to me that the Atlantic and Pacific branches cover the entire field of igneous rocks. This is certainly the view taken by Harker in his *Natural History of Igneous Rocks* (chap. iv), although the terms Atlantic and Pacific themselves are based largely on the distribution of Tertiary igneous rocks. The actual basis of the classification, however, is chemical, and the above terms are due to a probably too wide generalization as to the distribution of the groups. If this is the case the spilitic suite is merely a subdivision of the Atlantic branch, as its characters agree well enough with the definition of the latter (Harker, op. cit., pp. 90, 91).

Exceptions to that geographical distribution of igneous types implied by the use of the terms Atlantic and Pacific are now multiplying at such a rate that it may be necessary to drop those terms in their petrographic sense. In that event future research may show that the igneous rocks are divisible into more than two main classes, distinguished by broad chemical and mineralogical characters, and associated with various types of earth-movements. The spilitic suite may form one of these classes; but what I wish to point out is that as at present defined it seems merely to form a part of the Atlantic kindred, using that term in the sense that petrographers use it, to indicate the great division of 'alkalic' rocks. Messrs. Dewey and Flett consider that a close parallel exists between the spilitic suite and the analcite-bearing igneous rocks of the Scottish Carboniferous (p. 209). If so, there seems no reason why the latter, or indeed any well-marked group, should not be elevated to the rank assigned to the spilitic suite by the authors.

Another point concerns the status of the Tertiary igneous rocks of the Western Isles of Scotland. Messrs. Dewey & Flett consider that they belong to the Atlantic branch (p. 242), but advance no reasons for that view, which is, of course, in flat contradiction to that of Mr. Harker. No comment need be made save that it requires more than a mere *ipse dixit* to reverse Mr. Harker's opinion as to their Pacific relationships expressed in his *Tertiary Igneous Rocks of Skye* (1904), p. 417 (although the actual term Pacific is not here used), and later in the *Natural History of Igneous Rocks* (1909), pp. 99, 108.

G. W. Tyrrell.

Geological Department,
University of Glasgow.
June 8, 1911.

OBITUARY.

REV. ROBERT BOOG WATSON, B.A., F.R.S.E.

Born 1824 (?). Died June, 1910.

We learn from the address of Professor Watts to the Geological Society, 1911, of the death last year of the Rev. R. Boog Watson. His most important geological paper, "On the Great Drift Beds with Shells in the South of Arran," was published in 1864 (Trans. Roy. Soc. Edin., xxiii). His observations led him to conclude that all the latest geological changes have not materially affected the relations of hill and valley; that the valleys were largely excavated by ice; that the ice covered the land until it was submerged; and that the depression of the land below the sea was continuous, and ultimately attained 1,000 feet at least. Another paper, "On the Marine Origin of the Parallel Roads of Glen Roy," was published only in abstract (Quart. Journ. Geol. Soc., xxii, p. 9, 1865).

Mr. Vernon Austin.—We regret to record the death on June 9, in his 70th year, of Mr. Vernon Austin, son of the late Mr. Stephen Austin, and the last of that name to represent the highly respected firm of Stephen Austin and Sons, Printers, Hertford (established for more than 100 years), who have printed the Geological Magazine since December, 1865, a period of forty-five years. The firm is now carried on as Stephen Austin and Sons, Limited, Printers, Hertford.

MISCELLANEOUS.

The President of the Board of Education has appointed Mr. H. H. Thomas to succeed Dr. J. S. Flett as Petrographer to the Geological Survey of Great Britain.

Royal Society Conversazione.—Among objects of geological interest displayed at the conversazione on May 10 were—(1) Footprints from the Permian sandstones at Poltimore, Devon, exhibited by Principal A. W. Clayden. They bear a general resemblance to those obtained at Corncockle Moor and Penrith, though differing in detail. (2) Skeleton of *Ornithodesmus latidens*, a Pterodactyl from the Wealden shales of Atherfield, Isle of Wight, exhibited by Mr. R. W. Hooley.

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ASSISTED BY

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DR. GEORGE J. HINDE, F.R.S., F.G.S.
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HORACE B. WOODWARD, F.R.S., F.G.S.

AUGUST, 1911.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VIII.

No. VIII.—AUGUST, 1911.

ORIGINAL ARTICLES.

I.—Sedgwick Museum Notes.

A New Fossil from Girvan.

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

(PLATE XV.)

Helminthochiton thraivensis, sp. nov. (Plate XV.)

Description. Body elongated, narrow, composed of a longitudinal series of eight imbricating plates, and marginal girdle (?) of spicules.

First or head-plate transversely subcircular, broader than long, smallest of the series; about two-thirds the length of second plate; surface gently convex, very weakly carinated in posterior median part; posterior edge arched back, slightly angulated and projecting; inferior surface with submarginal concentric thickening.

Second to seventh plates of nearly equal size and shape, transversely trapezoidal in outline, about twice as wide as long, bent down strongly on each side of median axial line at angle of about 90°; imbricating backwards in middle. Anterior margin broadly emarginate, being excavated by shallow rounded median sinus; lateral portions of anterior margin arched forward as rounded lobes, with outer (=inferior) angle broadly rounded and passing into inferior margin, which is nearly straight and parallel to axial line. Posterior margin angulated in middle line, projecting backwards as bluntly pointed broad lobe slightly overlapping succeeding plate behind. Posterior and inferior margins meet at obtuse angles, or in seventh plate at right angles. Surface of plates in middle portion of body marked by pair of faint shallow depressions diverging anteriorly and broadening to anterior outer angles. Middle portion of plates internally thickened in a transverse direction, so as to make internal casts somewhat saddle-shaped. Posterior margin of plates furnished internally with narrow thickening close to edge, with several much finer parallel linear thickenings behind it. Upper surface of second to seventh plates ornamented with two (or sometimes more) strong regular concentric striæ parallel to anterior and outer edges of plates, one being situated usually at about one-fourth the length and the other at one-half the length, with finer concentric striæ between them.

Eighth or terminal plate smaller, less strongly bent along middle, gently convex, semi-elliptical in shape, rounded behind, with submarginal concentric thickening around anterior and outer edges on inferior surface.

Surface of all eight plates covered with closely set pores (with a few larger ones interspersed) arranged concentrically in a somewhat obscure manner between the finer striæ near lateral margins.

Girdle covered with densely felted mass of small spicules.

Dimensions.

		mm.
Length of first (anterior) plate . . .	about	6 to 7
Length of other plates	,,	12 ,, 13
Width of first plate	,,	10 ,, 12
Width of other plates	,,	22 ,, 24
Estimated length of whole body . . .		85 ,, 90

Horizon and Locality. Starfish Bed (Upper Bala), Drummuck Group: Thraive Glen, Girvan. (Mrs. Gray's Collection.)

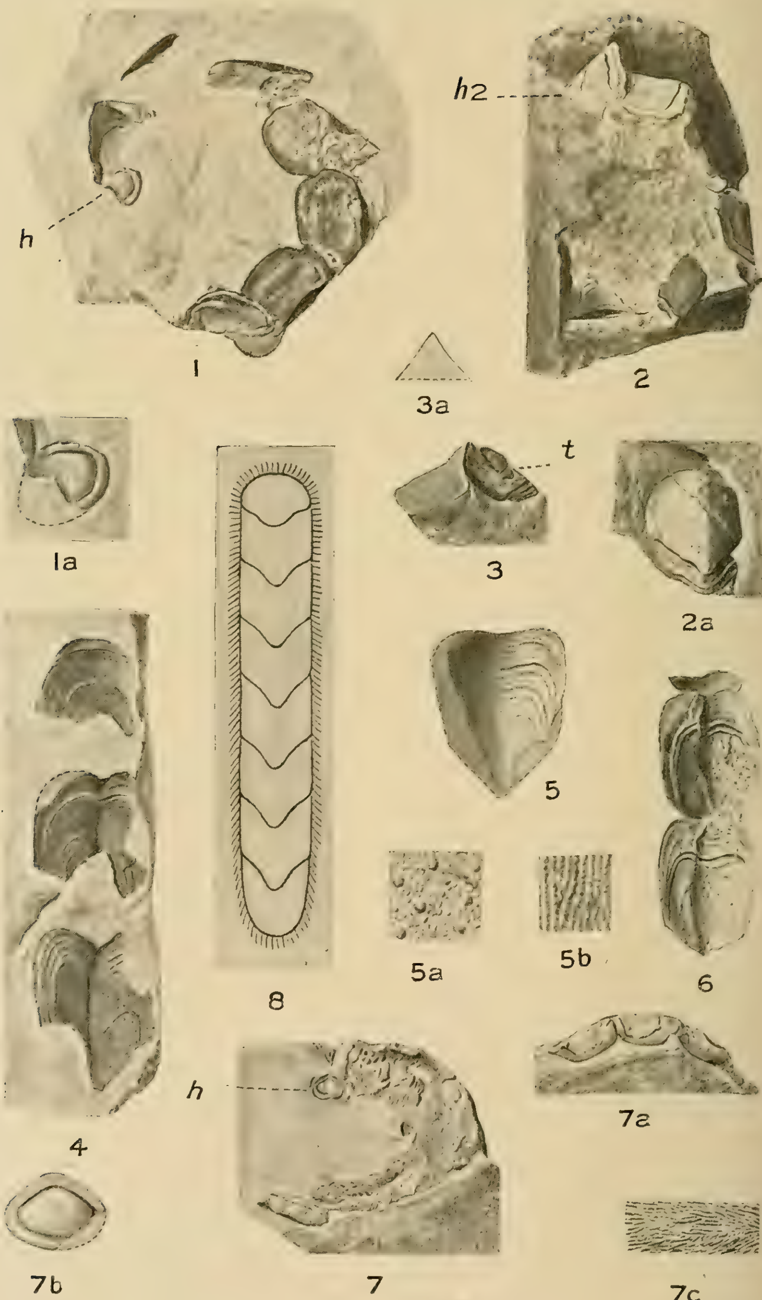
Remarks. There are several more or less perfect specimens of this new species in Mrs. Gray's Collection; one shows the whole eight plates in serial position, though they are not all perfect and most are in the condition of internal casts with portions of the external impressions of the plates here and there preserved. In all cases the shell is absent, and a cavity represents the space which it occupied before it decayed or was dissolved and removed. Two other specimens possess the first plate followed by several others in order, and there are examples of two or more associated middle plates.

Two nearly complete specimens of the whole mollusc exhibit a mass of spicules partly filling up the cavity of the body for its whole length and slightly extending below and outside the inferior margins of the plates, suggesting that the 'girdle' was dependent or incurved on each side instead of horizontally extended. The spicules occur as hollow casts in a densely felted mass, and must be interpreted as of the same nature as those developed round the marginal girdle of some living species of *Chiton*.

The minutely punctate or poriferous condition of the plates is clearly seen with a hand-lens in all the external impressions, and from the fact that the surface of the internal casts also shows a similar granular appearance, it may be concluded that the pores pierced the shell-substance. If this interpretation is correct, we may probably regard the pores as corresponding to the 'micropores' and 'megalopores' in living forms through which the network of nerves ('aesthetes') reach the sense organs on the outer surface such as Moseley[1] and many later zoologists[2] have described.

According to Fischer's[3] classification this new species should be placed in the subgenus *Eochiton* of his genus *Holochiton*, Plate (op. cit., p. 384); he considers that all the Palæozoic *Chitons* belong to the *Lepidopleurus*-stage of the group. The nearest affinities of the Girvan form are with *Helminthochiton Griffithi*, Salter,[4] which it much resembles in general shape and proportions. McCoy[5] in his figure and description of the latter species reversed its position, his cephalic plate being in reality

[1] Moseley, Ann. Mag. Nat. Hist. (5), xiv, p. 141, 1884.
[2] L. H. Plate, Zool. Jahrb., Suppl. v (1901), Th. C., p. 498, and references.
[3] Fischer, *Manuel de Conchyl.*, p. 877, 1887.
[4] Salter, Q.J.G.S., vol. iii, p. 48, fig. 6, 1847.
[5] McCoy, *Syn. Silur. Foss. Ireland*, p. 71, pl. v, figs. 5*a–e*.



T. A. Brock del.

Helminthochiton thraivensis, sp. nov.

the terminal plate, so that the other plates of the body are, as in the Girvan form, emarginate in front instead of behind as he described.

H. Grayiæ (Woodward)[1] is a much more slender and elongated form, and the coarse ornamentation of the plates is quite different, but in some specimens recently found by Mrs. Gray there are indistinct indications that the shell was minutely perforate as in *Hel. thraivensis*.

EXPLANATION OF PLATE XV.

FIG.

1. *Helminthochiton thraivensis*, sp. nov. Side view of internal cast of complete individual, showing the eight plates in position. Nat. size. h = head-plate.
1*a*. Ditto. Head-plate of same specimen. × 2.
2. Ditto. Internal cast of the five anterior plates of another specimen. Nat. size.
2*a*. Ditto. Second plate (h 2) of same specimen. × 2.
3. Ditto. Side view of internal cast of the two posterior plates of another specimen. Nat. size. t = terminal plate.
3*a*. Ditto. Transverse vertical section of same specimen, showing axial bending of plates. Nat. size.
4. Ditto. External impression of three successive plates, showing anterior emargination. × 2.
5. Ditto. External impression of another plate, showing general shape. × 2.
5*a*. Ditto. Portion of surface of adjoining plate, showing large and small pits. × 6.
5*b*. Ditto. Portion of ditto near margin, showing concentric arrangement. × 6.
6. Ditto. External impression of two other plates. × 2.
7. Ditto. Natural longitudinal vertical section of complete individual, showing mass of spicules. Nat. size. h = head-plate.
7*a*. Ditto. Side view of internal cast of three successive plates of same specimen. Nat. size.
7*b*. Ditto. Internal cast of head-plate of same specimen, viewed from above. × 3.
7*c*. Ditto. Portion of spicular mass of same specimen. × 3.
8. Ditto. Diagrammatic restoration of complete individual.

N.B. All the specimens come from the Starfish Bed (Drummuck Group), Thraive Glen, Girvan, and are in Mrs. Gray's Collection.

II.—On Dedolomitization.

By T. Crook, A.R.C.Sc. (Dublin), F.G.S., Scientific and Technical Department, Imperial Institute.

IT is a noteworthy feature of the most ancient crystalline limestones that they are generally dolomitic, or at any rate frequently so. They often consist of practically pure dolomite; whilst associated with this in some cases is pure crystalline magnesite,[2] which is very liable to be mistaken for saccharoidal dolomite.

Crystalline dolomites, dolomitic limestones, and their dedolomitized equivalents have a world-wide distribution among the usually much-metamorphosed pre-Cambrian rocks. In North America they are well

[1] Woodward, Geol. Mag., Dec. III, Vol. II, p. 352, Pl. IX, Figs. 7–10, 1885; Reed, ibid., Dec. V, Vol. IV, p. 113, Pl. IV, Fig. 12, 1907.

[2] Such crystalline magnesite occurs in Ceylon, as at Randeniya, Wellawaya. It occurs also in various parts of North America (see Dana's *System of Mineralogy*, 6th ed., p. 275) and elsewhere.

represented in the widespread pre-Cambrian rocks of Canada, and they also occur in the United States. In India and Ceylon they occur freely among the rocks of the fundamental complex. In Africa they are met with in the ancient and highly metamorphosed basement rocks of Nigeria, Rhodesia, Nyasaland, Natal, and other areas. In Britain, highly metamorphosed dolomites of Cambrian age occur in North-West Scotland, and others of uncertain age are also met with among the rocks of the Dalradian complex.

There appear to be very few, if any, exceptions to the rule that these ancient dolomitic rocks, especially those of the pre-Cambrian, have been thermally metamorphosed. The characteristic feature of this metamorphism is the production of secondary minerals in which magnesia plays a supreme part. Very often, indeed, lime does not enter at all into these secondary minerals, e.g. olivine, serpentine, mica (phlogopite or biotite, generally the former), periclase, brucite, spinel, and chondrodite.[1] In tremolite, which is fairly common as a secondary silicate in these rocks, magnesia predominates over lime, whilst in diopside magnesia and lime play equally important parts. It is of interest to note that picroilmenite occurs as a constituent of metamorphosed dolomite in Ceylon, associated with forsterite, phlogopite, and spinel. In all probability geikielite occurs in the same way.

Wollastonite, idocrase, and garnet (andradite and grossularite), which are common as secondary minerals in non-dolomitic crystalline limestone, are notable for their absence, at least as a rule, in metamorphosed dolomites; and it seems, indeed, highly probable that they cannot develop as the result of the direct thermal metamorphism of dolomite.

The production of secondary magnesian minerals, or minerals in which magnesium predominates over calcium, in thermally metamorphosed dolomite, necessitates the formation of calcite, as has been shown by Teall.[2] In those portions of the rock where sufficient silica was present, dedolomitization may be complete, or almost complete, and in such a case a rock may be produced consisting essentially of forsterite embedded in calcite, with very little residual dolomite. The forsterite marbles of Sutherland and Skye described by Teall[3] and Harker[4] afford examples of this type.

Hatch & Rastall have described a unique and extremely interesting case of the partial metamorphism of a lump of granite in dolomite, in which the inner reaction zone showed complete dedolomitization, accompanied by the formation of olivine, spinel, and brown phlogopite.[5] It appears, however, that dedolomitization so complete as this, in

[1] It is convenient to use the name chondrodite in a general sense for the members of the humite series when dealing with scattered granules in these rocks, since it is not practicable to identify any given irregular small grain with safety as belonging to any particular member of the series.

[2] See particularly *The Geological Structure of the North-West Highlands* (Memoirs of the Geological Survey of Great Britain), pp. 453–62, 1907.

[3] Loc. cit.

[4] *The Tertiary Igneous Rocks of Skye* (Mem. Geol. Surv.), pp. 144–51, 1904.

[5] Q.J.G.S., vol. lxvi, p. 507, 1910.

which the secondary magnesium minerals are left embedded in calcite, is comparatively rare. Usually the change is much less complete, and then the rule seems to be that the secondary magnesium minerals are embedded in dolomite and not in calcite.

Two specimens which serve as good examples of this have been examined by the writer and are worthy of description—one a forsterite-phlogopite marble from Peradeniya, Ceylon, the other a chondrodite marble from Verona, Ontario, Canada. In both cases the texture developed as a consequence of thermal metamorphism appears to have persisted in an undisturbed condition.

The Ceylon specimen[1] is one of massive coarsely crystalline dolomite, traversed by a band of secondary silicates consisting almost wholly of forsterite in the form of small greyish and rounded grains. Phlogopite is also present, but the amount is very small. Spinel, which is frequently present in Ceylon dolomites as a product of metamorphism, appears to be absent in this particular case. On either side of the forsterite band the rock consists of fairly pure dolomite, with only here and there a microscopic patch of calcite, and a few scattered granules of forsterite, which are embedded, not in the calcite, but in the dolomite. The carbonate substance of the forsterite

Fig. 1. Metamorphosed dolomite, from Peradeniya, Ceylon; showing forsterite in dolomite. Stippled portion represents calcite which was stained by the Lemberg solution. × 15.

band itself is largely but not completely dedolomitized; and even here, where the grains of forsterite are thickly set, they are never exclusively surrounded by calcite, and are generally embedded in dolomite (see Fig. 1). Judging from the relative amounts of calcite and forsterite present, it seems tolerably certain that the calcite present in the specimen has arisen entirely by dedolomitization, and that before metamorphism the carbonate consisted wholly of dolomite.

[1] This is a specimen of the Ceylon Mineral Survey collection at the Imperial Institute.

An examination of numerous sections of this Ceylon specimen showed a plentiful development of forsterite grains surrounded by coronas of dolomite, these being set in a matrix of calcite. The coronas are sometimes complete, sometimes broken, and often show attachment to adjacent patches of dolomite (Fig. 1). Here and there is seen a tendency to a linear arrangement, the adjacent coronas of dolomite coalescing in a manner which suggests eozoonal structure.

The secondary calcite contains numerous inclusions of dolomite. These inclusions are sometimes arranged in parallel layers (Fig. 1). Instead of parallel layers we may get a micropegmatite-like intergrowth [1] of the two minerals, or the dolomite may be scattered in the calcite in disconnected granules.

A feature of special note observed in the sections is that the streaks of dolomite intergrown with the calcite are sometimes connected with the dolomite coronas in such a way as to suggest that they served as channels along which magnesia was supplied to the coronas during the growth of the enclosed grain of forsterite.

The specimen of chondrodite marble from Ontario differs markedly from the Ceylon specimens just described in that the original rock was clearly a dolomitic limestone rather than a true dolomite rock, the amount of magnesia being small compared with that of lime. Here again, however, the secondary minerals which have been produced by metamorphism are free from lime (excepting calcite), the minerals observed being chondrodite, spinel, phlogopite, graphite, and pyrrhotite. As in the forsterite rock from Ceylon, these secondary minerals show a decided preference to be embedded in dolomite, though the amount of dolomite present is comparatively small. This is particularly the case with the grains of chondrodite. In the sections examined, each of the numerous grains of chondrodite had its corona of dolomite (see Fig. 2). Here again, in addition to the coronas, the sections show scattered grains and patches of dolomite in the calcitic matrix; and the simultaneous extinction of neighbouring patches of this dolomite, in some cases, suggests that they are portions of an anastomosing growth of dolomite. A pronounced feature in this specimen is the turbidity of the calcite as compared with the dolomite; this is a point which has been emphasized by previous workers who have described similar rocks.

Another specimen examined was kindly supplied by Dr. Hatch, from the outer ophicalcite zone of the Port Shepstone occurrence dealt with in the paper by Hatch & Rastall already referred to. This specimen is one of critical importance, owing to the definiteness of certain of the conditions of metamorphism in that particular case. As previously mentioned, it was shown by these authors that the inner reaction zone in the Port Shepstone instance was marked by practically complete dedolomitization. In the outer zone, however, one would expect the change to be far from complete; and the examination of a specimen of the ophicalcite proves this to be the case. Moreover, the coronal layers of dolomite around the grains of serpentine in this ophicalcite

[1] These peculiar intergrowths of dolomite in calcite appear to be identical with those described and figured by Coomaraswamy ("Crystalline Limestones of Ceylon": Q.J.G.S., vol. lviii, p. 412, 1902).

are better developed than in any of the other specimens which the writer has examined. The turbidity of the calcite as compared with the dolomite is a pronounced feature in the Port Shepstone specimen.

Several other specimens of metamorphosed dolomite from various localities, including Glenelg and Iona in Scotland, exhibit the same tendency to the development of coronas of dolomite around the grains of the secondary magnesium minerals (olivine and serpentine). The Iona specimen examined by the writer is of considerable interest as showing a streakiness or somewhat foliated character, arising from pressure-flow subsequent to thermal metamorphism. This pressure-flow has been accompanied by partial destruction of the enclosing shells of dolomite; but there can be no doubt that the texture originally produced by thermal metamorphism in this case was essentially similar to that of the Ceylon and Natal rocks described above.

Fig. 2. Metamorphosed dolomitic limestone, Verona, Ontario; showing chondrodite with an almost complete corona of dolomite. Stippled portion calcite. × 12.

Typical 'Eozoon' seems to afford a good example of a metamorphosed dolomite in which the dedolomitization is almost complete. Very little dolomite remains behind in the writer's specimen; this is sometimes in the form of scattered grains in the calcite matrix, but more commonly it forms partial coronas around the coalesced serpentine grains.

The petrography of 'Eozoon' strongly suggests that it was formerly a forsterite marble. Adams & Barlow, however, writing apparently with reference to the 'Laurentian' limestones of North America as a whole, state that "Olivine has never been found in these limestones; nor is there any reason to believe that it ever exists or ever did exist in them".[1] They hold the view that the serpentine in all cases has

[1] *Geology of the Haliburton and Bancroft Areas, Province of Ontario.* F. D. Adams & A. E. Barlow, Memoir No. 6, Department of Mines, Canada, p. 214, 1910.

been derived from pyroxene, a view which many will find it difficult to accept.

In making the above observations, the calcite and dolomite were distinguished from one another by staining with the well-known Lemberg solution—an aqueous solution of logwood and aluminium chloride. This is quite the safest means of discriminating between calcite and dolomite in rock slices, and never fails to give satisfactory results when properly managed. One should remember, however, that magnesite acts like dolomite in this respect, and remains unstained. The suspicion that some of the unstained portions of the slides might be magnesite led the writer to make density tests in several cases; but the results indicated that, in the specimens tested, the unstained material was dolomite.

To summarize the foregoing remarks, it appears from the specimens examined by the writer that one may represent the process of dedolomitization in three stages, viz.:—

1. Where the amount of silica is small we may get the magnesium silicates, etc., embedded in dolomite, with no calcite in their immediate vicinity. The calcite in such a case may be seen scattered in small patches in the dolomite, but noticeably remote from the secondary magnesium minerals; and in some cases we may get sections showing a considerable development of serpentine with practically no calcite.

2. A more advanced stage in dedolomitization is represented by the condition in which dolomite forms coronas round the grains of the secondary magnesium minerals. The calcitic matrix at this stage is usually interspersed with dolomite, which may be in the form of scattered granules or connected intergrowths. If the rock is coarse-grained the dolomite may be in the form of platy intergrowths showing parallel bands in section; and in such a case there appears to be a connexion between the platy intergrowths of dolomite and the dolomite coronas surrounding the grains of the secondary magnesium minerals.

3. In the most advanced stage, where the amount of silica has been sufficient to combine with the whole or almost the whole of the magnesia of the dolomite, the secondary magnesium minerals are left embedded in calcite. Any small amount of residual dolomite present in such a case may be in the form of scattered granules, or groups of granules, in the calcitic matrix; or may be left as broken remnants of the coronas around the grains of the secondary minerals.

The facts thus summarized are of considerable interest, partly as indicating the prevalence in thermally metamorphosed dolomites of certain textural features which have not been hitherto described, and partly also as throwing some light on the process of dedolomitization. There can be little or no doubt that such minerals as olivine, serpentine, chondrodite, phlogopite, spinel, and other magnesium minerals characteristic of crystalline dolomites and dolomitic limestones, are as a rule secondary to the dolomite. At least this has been clearly proved in many cases. There is, moreover, a close similarity between the facts of paragenesis and texture in all cases; and there seems to be no ground for Fermor's inference[1] that the dolomite and

[1] "Petrology of Chhindwára": Rec. Geol. Surv. Ind., vol. xxxiii, pt. iii, 1906.

calcite, in the rocks described by him, have arisen by the alteration of silicates under the influence of carbon dioxide.

It seems equally clear, however, that the process of dedolomitization is not quite so simple as has been supposed, and its explanation seems to call for still more facts.

III.—The Granite Mass of Foxdale, Isle of Man; with some notes on Dendritic Markings in Microgranite Dykes.

By William C. Simmons, B.Sc., A.R.C.S.

(MAP, PLATE XVI.)

THE mining village of Foxdale, situate a little towards the southern end of the north-east to south-west central trend-line of the Isle of Man, lies just north of the barren heath-covered hill called "Stoney Mountain". On the 6 inch Ordnance Survey Map the northern part of this hill is called Granite Mountain and the southern portion Windy Common. The whole forms a long, regularly sloped hill with its greatest length—about 2 miles—approximately north and south. Though of small altitude its singular barrenness makes it conspicuous in a moderately well-cultivated district. To the west South Barrule and the Barrule Slate Quarries rise considerably above it, though on the other sides the ground slopes gently off to more distant hills.

The granite occupies only about a third of the whole area of Stoney Mountain, and that all at the northern extremity. A small isolated exposure of the granite occurs a short distance to the east, near the little village of Eairy. These granite masses are intrusive into the Manx Slate Series, which have been in places considerably altered.

In both the larger Foxdale granite mass and the latter smaller one thick veins of quartz and coarse pegmatite occur. Sometimes these quartz veins, then resembling dykes, are found outside the granite intruded into the country rock. Lastly there are the characteristic microgranite dykes, associated with the granite mass and usually intruded in the slates with a N.E.–S.W. trend.

The field relations of the "Granite and its Elvans" are discussed in the Survey memoir of the Isle of Man (G. W. Lamplugh, 1903), to which also notes on the petrology of the rocks by Professor Watts are appended. Much quarrying has since been carried on in the quartz veins for silica, and consequently better sections can now be seen. It seems that a few further notes upon these very peculiar 'quartz dykes' may not be out of place.

Mr. Lomas[1] has described some of the veins and gives a rough description of their distribution, arriving at the conclusion that both those in the granite and those in the country rock are of igneous origin. Beyond brief notices in the Survey memoir and elsewhere, and a short description by Mr. A. Harker,[2] little other literature on the matter has come to hand.

[1] Lomas, Geol. Mag., 1903, pp. 34–6.

[2] A. Harker, *Naturalist* (Leeds), March, 1894 (note). Id., "Grainsgill Greisen": Q.J.G.S., vol. li, p. 143.

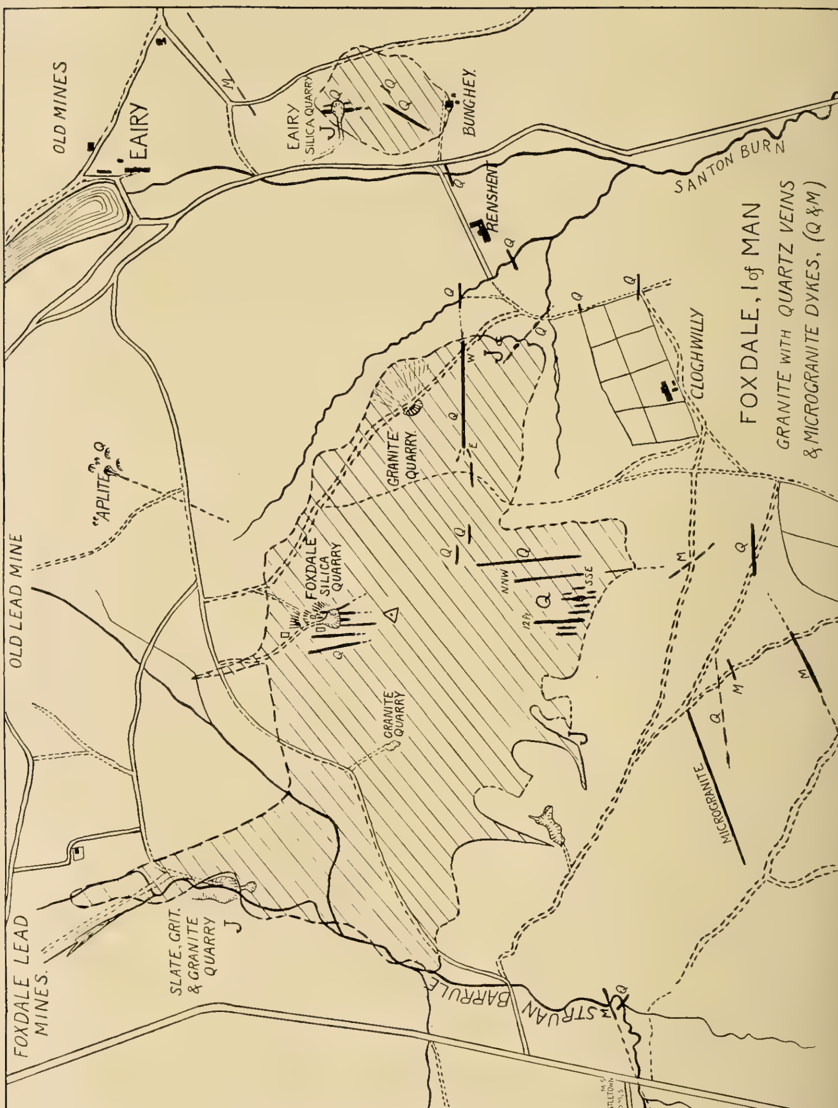
Description of the Map. (Plate XVI.)

The map is on the scale of 4 inches to 1 mile, and shows the shape of the outcrop of the granite mass. At the points marked J actual junctions between the granite and the altered country rock are exposed. Elsewhere the boundary is lined or dotted according as to whether the mapping is certain or only probable.

In the quarry below the Foxdale lead-mines (see Map, "slate, grit, and granite quarry") a good junction is seen. Between the granite and the slate a thick vertical strip of finer-grained granite occurs, which is continuous with a fine micrograuite dyke on the other side of the quarry.

Tracing the boundary south it can be seen to cross the stream (Struan Barrule) in several places and then to sweep east up the hill till we come to the apophyses marked on the map. These apophyses can be easily traced round the slate quarry, and at J is the slickensided junction with a dip of 30° (approx.) to the south-east under the slates, described in the Survey memoir. The granite of the apophyses is very fine-grained, or rather, contains strips of fine-grained micro-granite. Further east the boundary is somewhat obscured by bog, but is fairly clear as one approaches the farmstead of Renshent, where a junction with highly altered slates is seen in a little cutting. Then no other junctions are seen till the Foxdale Silica Quarry is reached (see Section, Fig. 2, p. 349), north of which a small apophysis runs out from the granite (Survey memoir, p. 165).

So far we are more or less in agreement with the Survey 1 inch map, but on this map the quartz veins are not shown. There may be other veins besides those shown upon the accompanying map, as there is considerable peat and boulder-drift, but the main veins are indicated as far as they can be traced. It will be noticed that these veins lie in three sets, somewhat radial, or approximately in two directions, viz., north and south, east and west. In the Foxdale Silica Quarry (Fig. 2, p. 349)—"the Spar Quarry"—there are several thick veins to be later described. The veins occur in greatest number to the south of the intrusion and several of them are 12 feet thick, while one for a short distance attains a thickness of 18 feet, but soon thins out to 2 or 3 feet on either side. Opposite Renshent (see Map, Plate XVI) a vein 12 feet in maximum thickness can be traced some way up the 'mountain', and it seems as though it is continuous with the vein outcropping in the stream to the east, but there is boggy ground between. The Eairy granite mass to the east is a smaller mass in every way similar to the main outcrop. Between the two outcrops the slates and grits are much altered and are exposed in the little stream. In the Survey memoir the question is raised as to whether this Eairy mass is connected with the Foxdale mass below or as to whether it is merely a portion of the latter that has been thrust into its present position. Since the Survey visited the spot a section of the junction of the granite with the slate has been exposed by quarrying in the Eairy mass for silica, and there seems evidence here that the mass is *in situ* and is a similar and connected intrusion. (See description of Section, Fig. 3, in Eairy Silica Quarry.)


FOXDALE, I of MAN
GRANITE WITH QUARTZ VEINS
& MICROGRANITE DYKES, (Q & M)
OLD MINES
EAIRY
EAIRY SILICA QUARRY
BUNGHEY.
SANTON BURN
RENSHENT
CLOGHWILLY
GRANITE QUARRY.
"APLITE"
OLD LEAD MINE
FOXDALE SILICA QUARRY
NNW
SSE
GRANITE QUARRY
MICROGRANITE
FOXDALE LEAD MINES.
SLATE, GRIT. & GRANITE QUARRY
BARRULE
STRUAN
CASTLETOWN

Quartz and pegmatite veins occur in this mass also. The boundaries, except at the above-mentioned junction, are nowhere seen owing to thick boulder-drift. The distribution of the heath and boulders and the levels give the probable mapping.

THE QUARTZ VEINS.

The Foxdale Silica Quarry (see Map, Plate XVI, and Section, Fig. 2, p. 349).

Judging from the surface outcrops of the pegmatite veins an observer sees little to lead him to any other conclusion than that these consist simply of walls of white quartz spangled in places with mica, which project through the peat among the granite blocks and can be traced for a considerable distance up the mountain. They seem on the surface to be simple dykes; but when exposed in section in the quarries the apparent simplicity gives way to a complexity at first confusing, but which a little consideration easily elucidates. In the quarry the 'dykes' are seen to be thick, nearly upright veins which send out offshoots into the granite, dipping up at a high angle. The figure gives a diagrammatic representation of the facts (Fig. 2). The quarry face is irregular, and in the sketch the whole is brought to one plane. The main veins are the two upright ones to the right of the figure. The larger does not reach up to the surface, and it sends offshoots to the right which have a high dip into the quarry face. The irregular surface is here largely due to irregularity in the quarry face combined with this high dip. To the left are three veins with a dip of approximately 45° to the west, and farther out a larger vein is seen which includes parts of the granite. The whole of the material between the veins is a rather coarse-grained muscovite granite. The quartz locally passes into pegmatite, which consists essentially of quartz with spangles and matted masses of pale-bronze coloured mica, which is of the same type as the mica of the granite.

Several interesting things are to be observed in this quarry. In one case (not shown in the Figure) a vein occurs which is practically upright and has on its sides a felted mass of pale-bronze mica between it and the granite. This selvage is about half an inch in thickness and could be traced for two or three yards. On the west side of the quarry a vein occurs which can be seen running up the hill for some distance (see Map). In a little cutting outside the quarry the whole of the vein for a short distance has been cleaned out, and the side walls remain perfectly smooth and upright. These walls consist of granite with a coating of a mixture of quartz and orthoclase felspar, half an inch and less in thickness. This is a peculiar selvage; the felspar is idiomorphic and the quartz more or less allotriomorphic though with parallel growth, and it is quite water-clear. The selvages are of importance in considering the origin of the quartz veins.

Another interesting fact here is the occurrence of 'lochs' in parts of the quartz veins. Large drusy cavities occur which are lined with good quartz crystals, in continuity with the quartz of the vein, and usually therefore there is a tendency to a parallel growth in them. Rarely the crystals are water-clear, but usually they are milk-white, like the veins themselves (due to inclusions, see Mr. Lomas' paper). These druses, called 'lochs' by the quarrymen, are said by them often to contain water. Now the veins are much jointed and cracked, and after breaking open many blocks with druses we succeeded in finding one or two containing water, but which evidently had filtered in along the cracks, as attested by the iron-stained path taken by it. All the quartz veins in the Foxdale Silica Quarry are of one type. They consist of almost pure quartz crystallized on a large scale, sometimes with flakes of mica. These are the quartz veins proper. At Eairy Quarry we get also fine-grained quartz-mosaics, forming the vein instead of the large crystals seen at Foxdale Quarry.

The Eairy Quarry (see Map, Plate XVI, and Section, Fig. 3, p. 349).

It is here that a junction of the slate with the granites may be seen, and here are thick pegmatite and quartz veins, with microgranite and granite giving an interesting section. The Figure (Fig. 3) explains itself. There is here much glacial drift covering the rocks, giving in one case quite a peculiar fold to the fragments.

The junction of the slates with the granite is quite a normal one, and the former are altered to mica schists and phyllites close to the granite. If the Eairy granite mass has been thrust off from the larger Foxdale mass, then the junction and slates too must have been subjected to the thrust. This does not seem probable, but evidence is wanted to prove that the slates are continuous with the main mass of the country rock. It should be noted that in few places are the slates so altered as between the two outcrops of granite. In the quarry section, next to the junction, a thick mass of jointed pegmatite cuts across the granite and slates (Fig. 3, *P*, *P*). It consists of quartz with large spangles of mica. The joint planes run at a steep angle to each other, and between the planes in two or three places a deposit of brown powdery limonite occurs, in one case as much as a foot thick, but shading off rapidly upwards. This is bounded further in the quarry by several faults with quartz and microgranite between them. These faults are also full of limonite. The mass of microgranite next shown is a fine granite very similar to the normal microgranite dykes associated with the granite. It is in parts stained by infiltered limonite and hæmatite along the joints which make dendritic markings, comparable with those found on Windy Common to the south, mentioned later.

A thick vein of quartz follows with a dip of about 75° to the east. This sends an offshoot into the microgranite. Lastly, there is another quartz vein separated from the former on both sides of the quarry by a wall of granite, but they run together through the granite in the centre. These last two veins of quartz contain little mica, but are much stained by infiltered iron-bearing water to yellow, brown, and red.

Mr. Harker describes the Foxdale granite thus: "It consists of quartz, microcline, an acid plagioclase, muscovite, subordinate biotite, and little crystals of garnet and zircon. In the marginal part of the intrusion are developed bands and masses of pegmatite, thick veins and bands of greisen, and finally quartz veins containing only local aggregations of white mica or bordered by a narrow seam rich in that

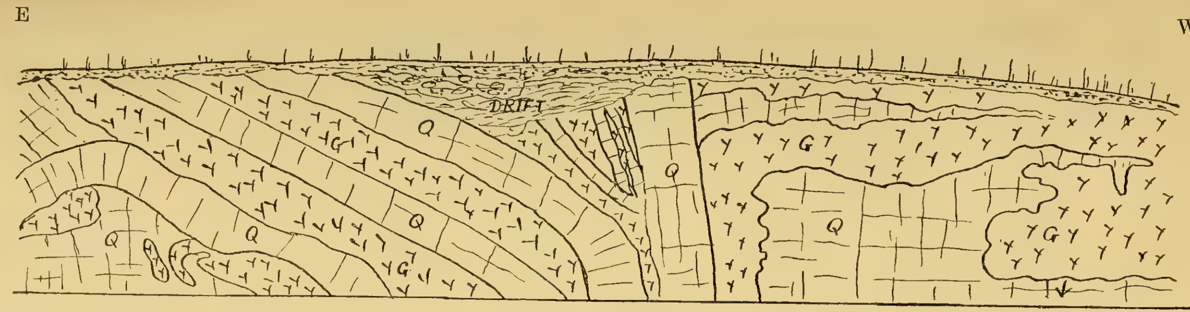


FIG. 2. Diagrammatized Section of quartz veins (Q) in granite (G) exposed in the Foxdale Silica Quarry. (See Map, Plate XVI.)

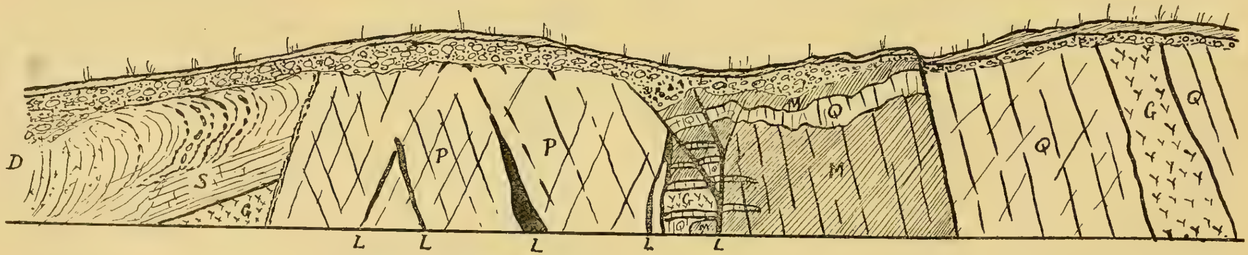


FIG. 3. Section in Eairy Quarry. (See Map, Plate XVI.)

Q. Quartz veins } including Harker's
P. Pegmatite } 'Greisen'.
M. Micrognanite (with Dendrites).
G. Granite.

S. Slates (altered).
D. Glacial Drift.
L. Limonite in joints.

mineral. These quartz veins, as at Grainsgill, traverse the other types of rocks."[1] It is significant that here in the Skiddaw granite quartz-mica pegmatite and small quartz veins occur. The north-eastern trend-line of the Isle of Man strikes into the Lake District, and the Manx slates have been long supposed to be comparable with the Skiddaw slates.

Pegmatite is seen in the Eairy Quarry and marked 'pegmatite' on the diagram. Mr. Harker uses 'greisen' to denote a rock with felspar in subordinate amount, with a rather coarse-textured mosaic of quartz and the mica in moderately large flakes. No topaz or cassiterite are present. No felspar has been found in the quartz rocks in Eairy Quarry, but rocks consisting simply of a mosaic of quartz and mica are present and here are included among the pegmatite. In only one case was a pegmatite found with felspar. A block of large-grained pegmatite with quartz, muscovite, and kaolinized felspar was found near the Foxdale Silica Quarry, but not *in situ*. In the Eairy Quarry the coarseness of grain of the quartz rocks varies considerably. Some of the pegmatite is very coarse indeed, the quartz grains often too large to trace. In some cases the quartz consists of a mosaic with flakes of mica, and this may possibly correspond with Mr. Harker's 'greisen'. It should be added also that there is considerable evidence of dislocation and disturbance in this Eairy Quarry. Besides the limonite-filled joints, pressure effects are seen in the pegmatite, and in one case a large lenticle of quartz covered with a shining film of mica was found. The granite shows a tendency to foliation in thin section.

Mode of Origin of the Quartz Veins.

One cannot help speculating upon the possible ways by which these characteristic pegmatite and quartz rocks can have been formed. The veins of quartz occur, as seen, in the granite itself and also in the surrounding country rock. As far away as Fleshwick Bay, near Port Erin, on South Barrule and on Slieau Whaullian to the north-west, veins of quartz are found in the slates. These last, however, do not appear as dykes; they follow the cleavage of the slates in some cases, and in others cut obliquely across in strings and bands; sometimes they are in irregular lenticles. In Fleshwick Bay thick veins following the cleavage occur in the grits and slates seen there; the grit near the quartz veins is very much hardened by silicification. Here and on Slieau Whaullian sometimes the quartz veins occur in highly contorted slates, and the veins follow the intricate folds more or less closely. In these cases we have, it seems, water-formed veins—veins which have been formed by infiltration. On South Barrule both forms of quartz occur.

In the case of the veins in the granite, and of those 'dykes' of quartz in the country rock, the mode of formation seems to be in every way comparable with that of normal igneous rocks. Veins of aplite that occur in association with many of the acid plutonic rocks are often spoken of as representing the mother-liquor of the molten magma after the greater part has crystallized. In the normal

[1] "Grainsgill Greisen": Q.J.G.S., vol. li, pp. 143–4.

sequence of crystallization quartz is the final mineral to consolidate. We have seen from the quarry sections that the thick veins of quartz are not so regular as first supposed, and are usually inclined at angles with the vertical. It should be noticed also that sometimes the granite is veined and stringed with small quartz veins from $\frac{1}{4}$ to 3 or 4 inches in width. This is a local phase and occurs a little to the west of the summit of the hill. The evidence seems to warrant the idea that the veins of quartz represent the final consolidation product of the granite magma. If this is the case cooling must indeed have been slow to allow them to crystallize on such a large scale. The selvages found to some of the veins support this theory also. In one case there is a layer half an inch thick of mica in every way similar to the mica of the granite and of the pegmatite. In another case a lining of quartz and orthoclase felspar occurs as above described. It would seem that these linings are due to the mass of the molten silica with impurities being subjected to a process of segregation, the magma being mobile and the cooling so slow as to allow in the one case the mica and in the other the felspar to be separated and gathered together at the sides, and after an interval the silica to crystallize slowly. All the veins at present seen in the Foxdale Quarry show a very coarse structure, but, as stated, in the Eairy Quarry finer-grained quartz veins occur with also pegmatite. The quartz veins outside the granite are usually rather fine-grained.

At the point marked 'Aplite' on the Map (Plate XVI) a quartz rock of doubtful nature occurs. It resembles a dyke in its field relations, but the exposure is not good. It is associated with sheets 3 inches thick running in the slates parallel to the bedding, and though at first taken for a dyke it more probably is an altered grit faulted off on one side. In section it most resembles an impure quartzite.

There is a decided break between the consolidation of the plagioclase and the quartz, and the former occurs always in well-lamellated idiomorphic crystals. In a section of the granite from the Foxdale Silica Quarry all three felspars are present, and all the felspars as well as the muscovite include small fragments of quartz. The microcline is always interstitial. Garnet occurs in small irregular grains locally. Apatite is present, but not common. The rock is a soda granite with a rather high silica percentage. A good approximate analysis is as follows:—

SiO_2	72·5
Al_2O_3	16·3
Fe_2O_3 / FeO	2·5
MnO	—
CaO	1·1
MgO	0·5
K_2O	3·2
Na_2O	3·2
TiO_2	0·2
P_2O_5	trace
Cl	trace
H_2O	0·54
	100·04

The granite contains plagioclase and microcline as well as a little orthoclase locally. The dominant mica is muscovite. The order of crystallization of the constituents is as follows:—

Muscovite.
Plagioclase (chiefly albite).
Orthoclase (when present).
Quartz.
Microcline.

The analysis shows the rock to be of a normal soda-granite type with a high silica percentage. The results compare fairly well with the analyses of granites of the Lake District and Ireland, except that aluminium is in higher percentage and the alkalis a little lower.

The condition of affairs seems to have been this—the main mass of the magma cooled to form the acid soda granite of which the analysis is given, but at the last there was a residuum of silica which crystallized out to form the peculiar quartz veins which run through the granite. The veins are igneous in origin, and there is no sign of 'comb' or other structure to suggest that water or vapours have helped in the formation.

Dendritic Markings in the Microgranite Dykes.

On Windy Common, about two miles south of the 'Granite Mountain', microgranite dykes occur with also a few quartz 'dykes'. The latter run north and south, but the former, of which seven could be mapped, all run north-east to south-west. Several of these 'elvans' have been quarried, and some are still being worked. In one of the most actively worked dykes peculiar dendritic markings occur. They were first noticed by Professor Boyd Dawkins, who kindly directed me to the locality and placed his specimens at my disposal. The dendritic markings are solid—not marks on one plane on the surface of the rock, but marks due to the actual soakage of solutions depositing oxides of iron in the rock. They always start on a joint plane, the sides of which are stained with the iron oxide, and run varying distances into the microgranite. Broken surfaces parallel to the joint plane give numerous circular dark marks, and sections at right angles to the joint planes give irregular marks, sometimes dendritic, sometimes almost straight. In section under the microscope the rock is seen to be a microgranite with quartz, felspar (plagioclase and orthoclase), and muscovite. The mica usually exhibits a tendency to parallelism and other evidence of pressure is not wanting. The staining in section is seen to be merely infiltered colouring matter between the grains. The dendritic marks can be wholly dissolved out of pieces of the rock by hydrochloric acid, yielding a yellow solution of ferric oxide and the fragments becoming quite white. As stated above, the dendrites occur also at Eairy Silica Quarry, and here also one gets the typical surface markings, properly dendritic in outline. Specimens of the dendritic microgranite are very striking and the usual character of the rock is hidden by the dark staining. It is a peculiar infiltration effect which seemed worthy of notice in this place.

IV.—Formation of a Laterite from a practically Quartz-free Diabase.

By Professor J. B. Harrison, C.M.G., M.A., F.G.S., F.I.C.

Part II. Microscopical Evidence.

THE chemical evidence with relation to the formation of a laterite from a diabase was given in a paper in the March number of the Geological Magazine, pp. 120–3. Since that account was written I have made microscopical examinations of the materials therein described.

Thin sections of the diabase and of its crusts of laterite were specially prepared for me by Messrs. Voigt and Hochgesang of Göttingen, the slices of the laterite being cut through both the inner buff-coloured layer and the outer red one.

Structure of the Diabase.—When seen under the microscope the diabase proves not to be as fine-grained as it appears to be in the hand-specimen. It is a moderately fine-grained ophitic diabase or dolerite, in which the pyroxene has some tendency towards an idiomorphic or in parts a granular structure. The pyroxene is a colourless augite of high double refringence; in a few places its masses are bordered by minute patches of a greenish biotite, some small flakes and aggregates of which also occur here and there in the rock. The felspar appears to be almost entirely labradorite, although there are a few patches of non-striated felspar which may consist of orthoclase; these patches show some slight strain effects. There are a few small interstitial patches of a micropegmatite of two felspars; I could not detect with any certainty any micropegmatite of felspar and quartz, but there may be some present. There are also a few minute interstitial patches of augite with some undifferentiated matter. Most of the labradorite is in the form of relatively long prisms which vary to a considerable extent in their breadths, some resembling in their sections broadish plates. There are some large, very irregularly shaped granules of titaniferous iron generally of ilmenite type, and these are very irregularly and unevenly scattered through the rock.

As an unimportant accessory constituent a few small granules of olivine are present, whilst some long and very narrow prisms or needles of zoisite, and exceedingly rarely a short prism of apatite occur. Careful search has been made for quartz, but only a very few minute interstitial grains of that mineral have been detected; these, however, appear to be of secondary origin.

Numerous measurements have been made of the minerals present in the slices, with the following results, given in percentages of the constituents of the diabase by weight:—

	Slice I.	Slice II.	Mean.
Felspar	48·6	50·1	49·35
Augite	41·5	44·4	42·95
Biotite	1·7	·6	1·15
Magnetite . . .	7·0	4·8	5·9
Olivine	1·0	·2	·6
Quartz	·07	—	·04
	99·87	100·1	99·99

It is evident from the above that the augite of the diabase is either more calciferous than is shown by the calculation of the mineralogical composition of the rock from its chemical analysis given on p. 121 of this Magazine for March last, or else that I have not fully allowed in my measurements for the proportion of labradorite included in the ophitic areas of augite. The proportion of felspar found in the various series of measurements ranged from 44 to 50·5 per cent., those of augite from 44·1 to 44·8 per cent., of biotite from ·5 to 1·9 per cent., of olivine from nil to 1·0 per cent., whilst those of titaniferous iron-ore ranged from 4·7 to 13·7 per cent. The interstitial quartz detected varied from nil to ·08 per cent.

The slices have been most carefully searched for signs of incipient weathering. These are found to be more frequent and more marked in those parts of the slices which have been cut from the outer part of the diabase in contact with the crust of laterite than in the inner ones. The signs are far more marked in the felspar prisms than in the masses of augite. The few granules of olivine also show well-marked signs of incipient alteration along their cleavages.

I was not able to trace satisfactorily the changes along the cleavages and the lines of 'chemical weakness' of the felspar by the use under polarized light of ordinary microscopic objectives, although I used various powers up to and including a one-twelfth inch homogeneous immersion objective; but finally I succeeded in getting good results by the use of a Zeiss 4 mm. apochromatic objective with a No. 12 ocular, and possibly even more satisfactory ones using the same objective with a W. Watson and Sons' B analyser-eyepiece.

Among the weathering products present are a few scattered minute flakes of a chloritic nature; while the lines of chemical weakness and some of the cleavages in the plagioclase felspar are marked by very minute colourless scales and lamellæ of a mineral of somewhat higher refringence and distinctly higher birefringence than is the labradorite. These scales show a somewhat inclined extinction.

From their general properties the minute scales appear to be gibbsite or hydrargillite, a mineral which I have previously observed as a secondary product in some of the felspars of certain British Guiana rocks. I cannot detect any signs of carbonates in the slices. The weathering effects on the augite are more difficult to detect than are those in the labradorite. But along the cracks and cleavages of some of the augite masses there are minute scales similar in general character to those in the plagioclase, but which are of lower refringence and of somewhat lower birefringence than is the pyroxene; the major part, however, of the incipient weathering products in the augite are more or less opaque and are difficult or not possible to differentiate.

The Structure of the Laterite.—As already mentioned, the slices were cut through both the inner and the outer crusts of laterite so that it is possible to trace the changes and the differences in them. Under a low magnification the slices show very clearly the structure of the rock from which the laterite was formed, and this is far better marked in its inner than in its outer part. The former masses of augite are now occupied by reticulated intersecting lines and streaks of limonitic iron-ores which are of a more or less transparent orange-yellow tinge in the inner parts, but change to brownish-red and red translucent masses, with in places more or less opaque patches, in the outer parts. The former areas of felspar are outlined along the junctions of the former prisms of felspar by films of limonite, and so are the former cleavages and the lines of chemical weakness. The spaces between the films of limonite are completely filled with glimmering masses or aggregates of very minute scales of gibbsite, which mineral can also be detected more sparsely and irregularly distributed between the ferruginous reticulations in the former augitic areas.

The higher powers of the microscope show in the part of the laterite adjacent to the unaltered diabase a few minute fragments of unaltered, not-stripped felspar, but these are of very sparing occurrence; some small areas of felspathic micropegmatite, in which one of the felspars is more or less clouded whilst the other remains clear and transparent; small irregular areas or blebs of secondary quartz are of rather frequent occurrence, especially in the immediate vicinity of patches of micropegmatite; occasionally, but rarely, quartz occurs in hexagonal blebs; a few long and very thin prisms of zoisite can be found, whilst here and there are seen small patches of more or less chloritized or bleached biotite. In this part of the lateritic crust the original iron-ores are little, if at all, changed. By far the greater part of the felspar is altered into aggregates of minute scales of gibbsite, the nature of this mineral having been proved by comparison with gibbsite in some slices of highly bauxitic laterite. Some of the augite masses appear to be changed into or replaced by limonitic products *en masse*, many of these strongly resembling goethite; other portions are altered into aggregates of talc stained with ferruginous matter, while in a few places some of the augite has been altered to a light-brown mica; a few fragments of unchanged augite remain. But the most usual alteration of the augite is into interlacing streaks of limonitic hydrates of iron with sparsely distributed patches of very minute scales of gibbsite between them. The latter may be a product from small crystals of labradorite included in the augite. In the middle and outer parts of the laterite slices no remnants of unaltered felspar or of micropegmatite can be found, while the prisms of zoisite are indicated merely as ‘ghosts’; the talc and the secondary mica in the former augitic areas have disappeared and have been replaced by limonite or other hydrate of iron, and no remnants of unaltered augite remain. A few small patches of original mica still remain and are but little altered. The titaniferous iron-ore has undergone some changes, many of the granules showing evidence of having lost some of their magnetite, only the ilmenite remaining quite unchanged. The secondary iron-ores have in part segregated into aggregates which are generally of a reddish-brown to a red colour and in places are more or less opaque. Changes in the state of aggregation of the gibbsite are also indicated, many of the scaly aggregates showing rotating crosses under polarized light, and others show more marked concretionary structure, while in a few places the hydrate of alumina has assumed the form of angular platelets, some of which appear to be roughly hexagonal. Small granules of quartz exactly similar to those in the inner part of the laterite are present in considerable number, but in these slices of laterite they do not appear as abundantly in the outer crust as they do in the inner one; this, however, may be due to differences in the distribution of micropegmatite in the original rock.

The microscopical studies have afforded important corroboratory evidence to that supplied by the chemical examinations. Like the latter they indicate that, at any rate in the case of a diabasic rock, the changes which result in the production of a laterite are exceedingly simple, and are such as would result from the mass-action of percolating rain and soil waters through very long periods of time. In the case of the felspar I cannot trace any production of hydrated micas or of kaolinite as intermediate between the plagioclase and the gibbsite. In that of the augite the change appears to be nearly but not quite as simple; in its case talc appears to be in part an intermediary product directly from the pyroxene, whilst a ferruginous mica seems to be a temporary product from the possible interaction of some of the constituents of the augite and of the orthoclase fraction of the felspars. The fact of the deposition of part of the silica set free by the weathering of the silicates in the form of more or less irregular granules of quartz is fully corroborated.

The comparisons of the inner and the outer parts of the lateritic crusts indicate that subsequent to the changes which gave rise to the laterite there were changes in the state of aggregation and of the hydration of the oxide of iron due doubtless to its solution and redeposition, whilst indications are not wanting that the gibbsite is subject, but to a lesser extent, to similar changes.

The examinations have thrown little light on the production of the masses of bauxitic laterite, in which much of the hydrate of alumina appears to be in a colloidal state.

V.—What is a Metamorphic Rock?

By Professor E. H. L. Schwarz, A.R.C.S., F.G.S., Rhodes University College, Grahamstown, South Africa.

The latest book on metamorphism, Dr. V. Grubenmann's *Kristallinen Schiefer*, still leaves it an open question what a metamorphic rock is. Generally speaking there is no doubt about the matter; every geologist has a more or less precise idea of what he means by the term, but no one has yet been able to propound a definition which is perfectly satisfactory, and which will enable one to distinguish a metamorphic rock from all other kinds and at the same time convey an expression of the characteristic peculiarities inherent in such a rock. The need of a definition is very necessary. The want of it has led Dr. Grubenmann to include some rocks among the crystalline schists which one ordinarily would not refer to that class, and on the other hand there are some rocks frequently referred to that class which are not included. In the first case, the masses of emery form the twelfth group of Dr. Grubenmann's classification, yet the analysis of the Naxos emery, which reveals traces of boric oxide (1·15 per cent. in one case) would seem to place these lenses among the ore-bodies deposited by pneumatolitic action. In the second case, the granulites appear to be genetically related to the eclogites and should find a place in a systematic classification of crystalline schists if the eclogites are included, whereas Dr. Grubenmann leaves them out though the eclogites are one of the rock-types included in his fourth group.

Van Hise logically defines a metamorphic rock as one that has been altered, and hence, as agents of metamorphism, we find listed plants, worms, burrowing animals, and man. One's dinner plate thus could be classed as a metamorphic rock, but it would be an unusual use of the term. There are conventional restrictions to such general terms, just as in the use of the word 'geology', which means the science of the world. If we were to apply Van Hise's logical use of terms, then we should mean by geology the science of everything on the earth and the *Encyclopædia Britannica* would be all too meagre a textbook. But while the old-fashioned expression 'mineral kingdom' usefully defines the subject-matter of geology, what are the restrictions that are to be observed in the use of the term 'metamorphic rock'? what is the subject-matter to be treated under metamorphism?

There is no doubt that the general usage is to exclude from metamorphism the change in rocks produced by weathering and also the change brought about by igneous fusion, whatever that expression means, so that we obtain an upper and a lower limit.

In the case of the upper limit, what amount of change is necessary in a rock for it to be taken from one of the other classes and placed in the metamorphic class? Certainly not the ordinary compacting of sediments, nor even the simple cementing of the grains by deposit from solution of silica, iron oxide or sulphide, calcite, etc., will make a sedimentary rock a metamorphic one; nor will the development of pegmatitic structure take an igneous rock out of its own particular class.

The development of secondary crystals in sedimentary or igneous rocks is again not sufficient to make a rock a metamorphic one. In the Carboniferous sandstones about Grahamstown the shaly laminæ are profusely scattered with scales of secondary mica (sericite), and these lie on perfectly unaltered Devonian shales; the sandstones have undergone a process of change precisely similar to that which produces a mica-schist, yet the micaceous sandstones are not metamorphic rocks. In the case of igneous rocks in the same way, diabases and melaphyres in which the augites, for instance, are entirely altered to uralite, are still igneous rocks, yet the process of alteration is the same as that which produces a hornblende-schist.

Dr. Grubenmann defines metamorphism as a process of rock-forming which is quite as characteristic as that which produces igneous or sedimentary rocks; it impresses on the crystalline schists their peculiar character and invests them with an independence as a class in contrast to other rocks. But what the 'stempel' or peculiar character is which, impressed on a rock, at once allows one to class it as a crystalline schist, Dr. Grubenmann does not say.

The crystalline schists, the same author says, are rocks which may have originated from igneous or sedimentary rocks, or mixtures of the two, in which the chemical composition has remained essentially unaltered. Consequently rocks of the same composition, no matter what their origin, under the same conditions of metamorphism, yield the same variety of crystalline schist. That is to say, a sandy dolomite with a layer of salt on top to render sodium to the mass, will, under the action of metamorphism, produce a diorite gneiss just as readily as an original diorite of approximately the same composition. Still, the amount of alteration necessary to change the sedimentary or igneous rock into a metamorphic one is left unexpressed.

If we take Dr. Grubenmann's three types of metamorphic rocks we seem to be near the possibility of a definition; there are, according to this author, rocks of three types, those belonging to the uppermost, middle, and lowermost zones of metamorphism, the first being represented by the phyllites and chlorite schists, the second by the schists proper (mica-, hornblende-schists), and the third by the gneisses and eclogites. The zones are marked off by the action of pressure. In the uppermost zone the pressure is stress (mass $\times$ motion) or, as we might call it, dynamical pressure; in the lowermost zone the pressure approximates to hydrostatic pressure, or pressure acting equally in all directions, which we can call static pressure. Under the action of these forces hydro-chemical processes have gone on in the sense that in the uppermost zone the compounds formed obey the volume law, that is to say, are those with the smallest molecular volume; in the lowermost zone the activity of the molecules is such that they are enabled to overcome the pressure from without and form compounds independently of the volume law. Thus, an impure dolomite might yield in the respective zones—

Uppermost zone. Garnet and quartz.	Molecular volume.	*Lowermost zone.* Augite and anorthite.	Molecular volume.
$Ca_2\,Mg\,Al_2\,Si_3\,O_{12}$	123	$Ca\,Mg\,Si_2\,O_6$	68·0
$Si\,O_2$	22·8	$Ca\,Al_2\,Si_2\,O_8$	101·1
	145·8		169·1

Under extreme pressure, where static pressure is alone active, the crystals will form without any reference to direction, which is produced by dynamical pressure, hence the minerals in the crystalline schist will crystallize as in an igneous rock. Here we come to the difficulty in defining the lower limit of crystalline schists; for if it be true that an increasing disregard of the volume law is characteristic of the lower zones, then the igneous rocks become simply metamorphic rocks in one stage lower than Dr. Grubenmann's lowest zone, thus:—

Lowermost metamorphic zone. Eclogite.	Molecular volume.	*Igneous rock.* Gabbro.	Molecular volume.
Garnet, $3\,R_3\,Al_2\,Si_3\,O_{12}$	369	Augite $\begin{cases} 2\,Ca\,Mg\,Si_2\,O_6 \\ Mg\,Al_2\,Si\,O_6 \end{cases}$	204·0
Omphacite, $Na\,Al\,Si_2\,O_6$	64·8	Olivine, $Mg_2\,Si\,O_4$	43·9
Quartz, $2\,Si\,O_2$	45·6	Anorthite, $2\,Ca\,Al_2\,Si_2\,O_3$	202·2
		Albite, $Na\,Al\,Si_3\,O_8$	100·3
	479·4		550·4

It is very generally held now that igneous fusion of rocks is accomplished with the help of water; whatever rock we examine, whether it belongs to the acid series with micas which contain combined water, or to the basic rocks (perhaps with the exception of some of the ultra-basic rocks), there is always evidence that a part of the peculiarities exhibited by it must be explained by aqueous solution. Quartz is readily soluble in water at 200° C., and becomes a powerful acid like nitric or sulphuric acid; the solution becomes a solvent in which bases can be dissolved, and on cooling or supersaturation these would combine with the silica to form the various minerals of igneous rocks. The pegmatites and quartz veins which come from granite masses can be regarded as the end products of a series of crystallizations which began by the formation of the normal granite and which were accomplished by hydro-chemical processes. There is the old experiment of Fouqué and Michel-Lévy of fusing microcline and biotite; the melt on crystallizing gave leucite, olivine, and magnetite. If it be objected that the pressure on the earth's crust was the only thing needful to keep the chemical combination represented by microcline and biotite, we have Oetling's experiments to contradict such an assumption. Oetling,[1] on fusing the rock-forming minerals under pressure, found that the melt solidified as a glass, whereas under ordinary pressure they crystallized, sometimes as the original minerals, sometimes, as in Fouqué and Michel-Lévy's experiment, in other forms. Whichever way we attack the question we find that solvent water is the agent active in forming the characteristic minerals and structures of igneous rocks: a discussion of the whole question, with references, is given in *Natural History of Igneous Rocks*, by A. Harker, pp. 294 et seq.

If this be so, then where are the dividing peculiarities between, say, a graphic granite and an eclogite? Both form dyke-like masses which may be in both cases in gneiss; both are holocrystalline with the crystals formed without reference to any leading direction, and more than one mineral may be common to both (quartz, felspar, hornblende, etc.), and yet the one is unquestionably a rock belonging to the so-called igneous class and the other to the metamorphic class. The answer seems to me to lie in a recognition that in the igneous rock some law of chemical combination has been carried out under circumstances which have allowed complete freedom of molecular action, whereas in the metamorphic rocks there have been restrictions. Using the fact that the sum of the molecular volumes of the minerals in an igneous rock are greater than the sum of the molecular volumes of corresponding minerals in a metamorphic rock of the same chemical composition, it is perhaps possible to define the differences in the two as due, in the one case, to the internal pressure (i.e. molecular activity) having been greater than the external pressure, and in the other that the reverse has obtained. In other words, if a rock magma is under sufficient pressure to allow the solid particles to move freely into the solvent water, the chemical affinities of the substances in the

[1] A. Oetling, "Vergleichende Experimente über Verfestigung geschmolzener Gesteinmassen unter erhohtem und normalem Druck": Tscher. Mitt., xvii, 1898.

magma are allowed to satisfy themselves without reference to any disturbing factor, and an igneous rock will result. If on the other hand the pressure is not sufficient to produce a complete fluidal phase, in Riecke's sense, but the whole rock remains solid except at the boundaries of the constituent grains where interchange of substance can take place, then the law of least molecular volume comes into play; the small amount of dissolved substance is restricted in its molecular activity, and a metamorphic rock is produced.[1] As the pressure approaches the static condition the mineral arrangement will tend to become massive like that of igneous rocks, and as the pressure decreases the lateral stress will produce more and more pronounced schistose structures.

If we accept some such definition of a metamorphic rock in terms of molecular energy we can apply it to separate such a rock at its upper limit, as well as at its lower limit, from other varieties. That is to say, a metamorphic rock must be one in which dynamical pressure has acted, and the term cannot be applied to one in which, owing to peculiar circumstances, a mineral usually associated with metamorphism has crystallized, as in the micaceous sandstones referred to above.

A metamorphic rock under this conception could not arise between two sedimentary rocks, or in the midst of an igneous mass, because the metamorphism, being due to hydro-chemical reactions under dynamical pressure, will be a measure of the 'head' or pressure on the water which permits the chemical activity to proceed. Water under such a pressure will permeate all the surrounding rocks irrespective of their texture or composition, and therefore there can be no selective action on particular zones of the rock-complex, but there will be a progressive intensity of metamorphism from above downwards. Mere accession of heat will not produce a metamorphic rock; for example, the anorthosites of Canada are traversed by bands of brecciation in which the rock is reduced to a 'Rutschmehl'; in Madras, in the charnockite gneisses, similar bands or 'trap-shotten' are produced in which the temperature has risen sufficiently to partially fuse the rock,[2] but these mylonites are entirely different from metamorphic rocks.

In the case of contact metamorphism the same explanation will simplify considerably the interpretation of the phenomena. Along the course of the dyke, or in the neighbourhood of the intruding boss or laccolite, the water pressure will be temporarily increased to such a degree that metamorphic action can proceed. If the 'head' of the water is maintained either by fresh supplies from the invading magma or by the closeness of the texture of the rock suddenly subjected to the increased water pressure, then metamorphic action will go on vigorously; if, however, the surrounding rocks are not sufficiently compact, or the invading rock is not pumping up sufficient water to

[1] E. Riecke, "Über das Gleichgewicht zwischen einem festen, homogen deformierten Körper und einer flüssigen Phase, insbesondere über die Depression des Schmelzpunktes durch Spannung": Nachr. Ges. Wiss. Göttingen, iv, p. 278, 1894.

[2] T. H. H. Holland, Mem. Geol. Surv. India, vol. xxviii, pt. ii, p. 198, 1900.

maintain the pressure, then the metamorphic action will not take place and a granite or dolerite may come to rest against a slate without showing the least sign of alteration at the contact.

The purpose of this note, however, is not to discuss the whole subject of metamorphism but to draw attention to the want of definitiveness in the terms used by authors in describing the metamorphic rocks. It seems to me to be impossible to attain any definitiveness unless we use molecular energy as a basis: the mischief of this is that it makes it necessary for geologists to add to their already overburdened subject the additional trouble of physical chemistry.

Addendum.—Since writing the above I have received *Recherches sur l'exhalaison volcanique*, by A. Brun, in which it is recorded that certain of the metamorphic minerals, kyanite, epidote, vesuvianite, etc., have their crystalline structure destroyed at temperatures in many cases much below the fusion-point. Epidote, for instance, loses its crystalline structure at 900° C. and fuses at 1250° C.

Epidote = 2 H Ca_2 $(Al\ Fe)_3$ Si_3 O_{13}, molecular volume 296
Anorthite = 3 Ca Al_2 Si_2 O_8 ,, ,, 303·3

So that, in spite of its having within its molecular structure water, iron, and a surplus of lime, epidote has a far smaller bulk than the igneous mineral anorthite. The destruction of the crystalline structure by heat long before fusion seems to point, therefore, to expansion of the molecule. All the metamorphic minerals do not show this character, garnet and spinel for instance, but the presence in a rock of one mineral that does might be taken as an indication that the rock belongs to the metamorphic class.

VI.—On a large form of *Anthrapalæmon* from the Clay-ironstone Nodules of the Middle Coal-measures, Sparth Bottoms, Rochdale.

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

As long ago as 1836 Prestwich published his historical paper "On the Geology of Coalbrook Dale",[1] and in it he figured a Crustacean carapace under the name of *Apus dubuis*.

In 1861 [2] J. W. Salter figured and described some new Coal-measure forms of Crustacea which he referred to the genus *Anthrapalæmon*, gen. nov., and included therein Prestwich's *Apus dubuis*.

In my second year's Presidential Address to the Geological Society, in 1896, I dealt with the "Life-history of the Crustacea in Later Palæozoic and in Neozoic Times", and, under the Decapoda Macrura, I referred to those of the Coal-measures (Proc. Quart. Journ. Geol. Soc., 1896, vol. lii). "Eight species of *Anthrapalæmon* from the Coal-measures of Scotland and England, one from Illinois, U.S.A., and one from Nova Scotia, illustrate the abundance of these small Crustacea in the Carboniferous period. They have many points in common, but probably deserve more than specific differentiation.

[1] See Trans. Geol. Soc., 1840, vol. v.
[2] See Quart. Journ. Geol. Soc., vol. xvii, p. 530, 1861.

"With the exception of *Anthrapalæmon Parkii*, *A. Traquairii*, and *A. Etheridgei*, which measure from 3 to 5 inches, the other species do not exceed 1 to 2 inches in their entire length.

"The carapace and body-segments were evidently and usually broadly expanded, as in the Eryonidæ; the large scale at the base of the outer antennæ suggests the Penæidæ; the strong basal joints of the inner pair of antennæ with bifid flagella, and the outer pair with single ones, are like many of the modern Caridea and Astacidea; the caudal appendages forcibly recall the rhipidina of the living Galatheidæ, in which, as in some ancient forms, there are two additional broad lamellæ to the tail-fan, developed one on either side of the telson.

"In the spinose ornamentation of the somites and caudal plates, in the broadening out of the segments of the abdomen and the short rounded form of the cephalo-thoracic shield in *Anthrapalæmon Parkii*, one is reminded of the genus *Squilla*, though probably this is only an analogy" (pp. xcviii, xcix).

I quote this last paragraph to show that, in 1896, I had a strong conviction that these forms from Eskdale, placed at that time under *Anthrapalæmon* by Dr. B. N. Peach,[1] deserved to be referred to a distinct genus, and a recent study of the rich materials from Glencartholm in the British Museum convinces me of the propriety of their subsequent separation by him.

Dr. B. N. Peach's original essay already referred to (see Trans. Roy. Soc. Edinb., vol. xxx, p. 73, 1882; p. 511, 1883) was followed, in 1908, by a most important memoir, published by the Geological Survey of Great Britain, entitled "A Monograph on the higher Crustacea of the Carboniferous Rocks of Scotland", 4to (issued October 28, 1908), pp. 82, pls. i–xiii, in which, in addition to the specimens figured in the previous work, he incorporated all the new material added to the Survey Collection between 1883 and 1905, and made a complete and very careful revision of the earlier work.

The species dealt with are placed under the following genera, namely:—

Schizopoda.[2]	Group I, Mysid Group.	Lophogastridæ.	*Tealliocaris*, Peach, 1908, with 9 species and varieties.
			Pseudo-Galathea, Peach, 1883, with 3 species.
			Anthrapalæmon, Salter, 1861, with 2 species and varieties.
			Pygocephalus, Huxley, 1857, with 1 species.
		Perimecturidæ.	*Perimecturus*, Peach, 1908, with 7 species and variety.
		Anaspidæ.	*Palæocaris*, Meek & Worthen, 1868, with 2 species.
		Mysidæ.	*Palæmysis*, Peach, 1908, with 3 species.
	Group II, the Euphausid Group.	Euphausidæ.	*Anthracophausia*, Peach, 1908, with 3 species and varieties.
			Crangopsis, Salter, 1863, with 10 species.

[1] Dr. B. N. Peach, Trans. Roy. Soc. Edinb., vol. xxx, p. 73, 1882; p. 511, 1883.

[2] Without in any way desiring to detract from the great value and importance of Dr. Peach's monograph, it may be well to bear in mind the caution expressed by Dr. W. T. Calman in his review of Dr. Peach's memoir in the Geological Magazine for 1909 (pp. 76–8) as regards the reference of all these forms to the

The following is a list of the species mentioned by Dr. Peach in his memoir[1]:—

TEALLIOCARIS, Peach, 1908.
Tealliocaris loudonensis, Peach, p. 9.[2]
T. Woodwardi (R. Eth., jun.), 18.
T. Woodwardi, var., 22.
T. Etheridgei (Peach), 22.
T. Etheridgei, var. *lata* (Peach), 23.
T. robusta, Peach, 24.
T. robusta, var. nov., 25.
T. tarrasiana, Peach, 26.
T. formosa, Peach, 27.

PSEUDO-GALATHEA, Peach, 1883.
Pseudo-Galathea macconochiei (R. Eth., jun.), 28.
P. rotunda, Peach, 28.
P. ornatissima, Peach, 29.

ANTHRAPALÆMON, Salter, 1861.
Anthrapalæmon Grossarti, Salter, syn. = *Russellianus*[3] (Salter), 30.
A. Russellianus, var. *spinulosus*, Peach, 36.

PYGOCEPHALUS, Huxley, 1857.
Pygocephalus Cooperi, Huxley, 37.

PERIMECTURUS, Peach, gen. nov., 1908.
Perimecturus Parki (Peach), 40.
P. Parki, var. *duplicicarinatus*, Peach, 41.
P. Stocki, Peach, 42.
P. elegans, Peach, 44.
P. communis, Peach, 47.
P. ensifer, Peach, 49.
P. Pattoni, Peach, 51.

PALÆOCARIS, Meek & Worthen, 1868.
Palæocaris scotica, Peach, 54.
P. Landsboroughi, Peach, 55.

PALÆMYSIS, Peach, 1908.
Palæmysis Dunlopi, Peach, 57.
P. Couttsi, Peach, 59.
P. tenuis, Peach, 60.

ANTHRACOPHAUSIA, Peach, 1908.
Anthracophausia dunsiana, Peach, 61.
A. dunsiana, var. *obesa*, Peach, 66.
A. Traquairi (Peach), 67.

CRANGOPSIS, Salter, 1863.
Crangopsis socialis, Salter, 69.
C. Rhodesi, Peach, 73.
C. magna, Peach, 75.
C. Couttsi, Peach, 76.
C. robusta, Peach, 78.
C. minuta, Peach, 80.
C. Eskdalensis (Peach), 80.
C. elegans (Peach), 81.
C. hastata, Peach, 82.
C. Huxleyi (H. Woodw.), 82.

Of the more characteristic forms of the genus *Anthrapalæmon*, as defined by J. W. Salter, met with in Illinois, U.S.A., in Nova Scotia, at Airdrie (Lanarkshire), Ipstone (North Staffordshire), Shropshire, and Lancashire, it may be stated that the carapace is nearly quadrangular, the frontal border being nearly straight, and only a fifth less broad than the widest part of the carapace at its centre; the abdominal segments are short, hardly longer than the cephalothorax, which is nearly as wide as the carapace itself. The median ridge is well marked, also the cervical furrow; the front angle of the carapace has a sharp spine, and the rostrum is strongly produced

Schizopoda, some of which at least had been believed to belong to the Decapoda. Dr. Calman also expressed a doubt as to the determination of some of the species referred to *Crangopsis* and to the Euphausidæ; but space does not permit us to deal with these divisions satisfactorily here.

[1] See Geol. Surv. Mem., *Palæontology*, *Higher Crustacea of Carboniferous Rocks of Scotland*, 1908, E. Stanford, London, 4to, p. 6.

[2] The pages given here refer to Dr. Peach's memoir.

[3] *Anthrapalæmon Grossarti*, Salter, was published in 1861 (see Q.J.G.S., vol. xvii, p. 528, with woodcut), *Palæocarabus Russellianus*, Salter, in 1863 (Q.J.G.S., vol. xix, p. 520, figs. 1 and 2). I pointed out in 1866 (Trans. Glasgow Geol. Soc., vol. ii, p. 246) that *A. Grossarti* and *P. Russellianus* were *identical species*, and as the former had two years priority over the latter, the name *P. Russellianus* must disappear and become a synonym of *A. Grossarti*, Salter; see also Brit. Mus. Cat. of Brit. Foss. Crustacea, 1877, p. 8.

and ridged. Subjoined is a list of American species referred to the genus *Anthrapalæmon*:—

Anthrapalæmon Hilliana, Dawson, 1877. GEOL. MAG., Dec. II, Vol. IV, p. 56, Fig. 1. Coal-measures: South Joggins, Nova Scotia.

,, ,, Dawson, 1878. *Acadian Geology*, Supp., p. 55, fig. 10. Coal-measures: South Joggins, Nova Scotia.

,, *gracilis*, Meek & Worthen, 1865. Proc. Acad. Nat. Sci. Phil., vol. xvii, p. 50. Coal-measures: Mazon Creek, Grundy Co., Illinois.

,, ,, Meek & Worthen, 1866. Geol. Surv. Illinois, vol. ii, p. 407, pl. xxxii, figs. 4*a–c*; vol. iii, p. 554, figs. *a*, *b*.

,, ,, White, 1884. Thirteenth Report Dept. Geol. Nat. Hist. Indiana, p. 180, pl. xxxviii, figs. 8, 9.

,, ,, Packard, 1885. *American Naturalist*, vol. xix, p. 880.

,, ,, Packard, 1886. Mem. Nat. Acad. Sci., vol. iii, p. 135, pl. iv, figs. 1–3, 5, 6; pl. vii, figs. 3–6.

In 1905 I added a species of *Anthrapalæmon* (*A. serratus*) from the Lower Coal-measures, Colne, Lancashire (see GEOL. MAG., Dec. V, Vol. II, pp. 438–9, Fig. 1), and another (either *Pygocephalus* or *Anthrapalæmon* (?) *Parkeri*, H. Woodw.) from the Coal-measures of Sparth, near Rochdale (see GEOL. MAG., Dec. V, Vol. IV, p. 406, Fig. 2, 1907). I also gave a fuller account in 1907 (op. cit., pp. 400–7) of *Pygocephalus*, and figured and described the marsupial plates in the female of *P. Cooperi* (op. cit., Plate XVIII), not heretofore observed in a fossil Crustacean.

I am indebted to Mr. Fred Holt, of Rochdale, for the opportunity to figure and describe one of the largest specimens of an *Anthrapalæmon* from the Coal-measures I have yet seen. It was obtained from a concretion of clay-ironstone, on the reverse side of which several casts of Lamellibranch shells (*Carbonicola*, etc.) are exposed. Notwithstanding some irregular fractures the nodule exhibits on its upper surface the cephalo-thoracic shield of a Palinuroid, the contour of which, as well as the ornament on its dorsal region, is very well preserved (a thin crust-like cover represents the obverse of the cast which originally concealed the carapace from view).

Dimensions. Length of carapace, 42 mm.; greatest middle breadth, 36 mm.; breadth upon the front border of shield, 25 mm.; at posterior border, 20 mm.; the posterior border is strongly arched, rising 6 mm. at the centre on the dorsal line. The lateral borders are moderately expanded outwards, and the margin on either side is sharply serrated along the anterior half (Fig. 1*c*), ending in a prominent spine on the latero-anterior border. Inside the latero-anterior spines the frontal border is nearly straight or but slightly curved towards the rostrum, which is prominent and had one or more serrations on its basal portion. The dorsal ridge is prominent for 26 mm., when it is crossed by and subsides into the cervical furrow, which is strongly arched for 8 mm. on either side the dorsal line; it then bifurcates sharply anteriorly towards a submedian spine, and posteriorly to join a longitudinal furrow running obliquely to the posterior margin. The dorsal region of the carapace between these oblique longitudinal lines is ornamented with minute tubercles and fine anastomosing lines (see Fig. 1*b*), one rather larger tubercle than the rest occupying each interspace between the lines.

When compared with the beautiful series of figures given in Dr. B. N. Peach's monograph of the *Higher Crustacea of the Carboniferous Rocks of Scotland* [1] we find no fewer than seven figures on plate iv devoted by Dr. Peach to the illustration of *Anthrapalæmon Grossarti = Russellianus* (Salter), the species to which our specimen (here figured) is most closely related.

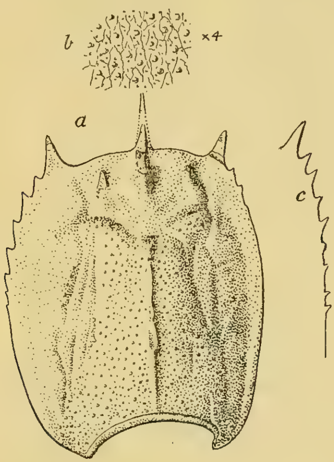


FIG. 1. Carapace of *Anthrapalæmon Grossarti=Russellianus*, var. *Holti*. Coal-measures: Sparth, near Rochdale. Obtained by Mr. Fred Holt.

Of these,[1] figs. 1, 4, 6, 7 (pl. iv, op. cit.), being views of the carapace, offer the best illustrations for comparison with our Sparth specimen.

Fig. 2 shows a carapace, partly decorticated, but having its lateral border nearly entire, with about eighteen serrations along its margin and exposing wide sternites and row of plates with gills and other organs.

Fig. 3 gives a side-view of the same species, showing endopodites and exopodites of trunk-limbs and gills attached to their bases; the eyes, antennules, and antennæ with rounded scales at bases of same.

Fig. 4 gives an excellent profile of another carapace of this species with the rostrum and hepatic spines preserved.

Fig. 5 shows four segments of the abdomen with terminal lobe (pygidium) and pleopods partly preserved.

Fig. 6 represents a complete carapace with abdomen attached (slightly displaced), showing pygidium and pleopods preserved.

Fig. 7, like fig. 1, shows a detached carapace (*A. Russellianus*, var. *spinulosus*).

It will be observed that in figs. 1, 2, 4, and 7, in which the carapaces of *A. Grossarti=Russellianus* are drawn, Dr. Peach shows that the

[1] See Mem. Geol. Surv. Great Britain, *Palæontology*, 4to, Glasgow, 1908, in which his previous memoirs (Trans. Roy. Soc. Edinb., 1882 and 1883) are incorporated (pp. 82, pls. i–xii).

serrations on the sides extend the entire length of the lateral border and are strongly and regularly developed, and that the surface ornamentation in figs. 1, 2, 3, and 4 is strongly scabrous and devoid of the fine anastomosing lines observed in the Sparth carapace.

In Dr. Peach's fig. 6 the ornamentation appears somewhat less rugose, and the serrations are confined to the anterior half of the lateral border, as is the case in our Rochdale specimen. The two lateral spines, one on either side of the rostrum (in our example) in the centre of the hepatic region, seem to be replaced in the Scottish specimens by an oblique line of five very small serrations.

In the absence of appendages it will suffice to draw attention to this very large and interesting carapace, which no doubt belongs to the genus *Anthrapalæmon*; it is doubtful, however, if it should be erected into a new species. It may suffice at present to refer to it as *Anthrapalæmon Grossarti*, var. *Holti*, var. nov.

I should mention that in another concretion from Sparth, also obtained by Mr. Fred Holt, there are parts apparently of a second carapace of *Anthrapalæmon*, quite as large as the first already referred to, but more shattered in situ. The complete carapace has its own counterpart, but that has been broken in removing it to expose the relievo side, and has since been joined together again.

REVIEWS.

I.—The Coast Scenery of North Devon: being an Account of the Geological Features of the Coast-line extending from Porlock in Somerset to Boscastle in North Cornwall. By E. A. Newell Arber, M.A., F.L.S., F.G.S. 8vo; pp. xxiv, 261, with 64 plates, 2 maps, and 12 text-illustrations. London: J. M. Dent and Sons, Ltd., 1911. Price 10*s*. 6*d*. net.

(PLATE XVII.[1])

THIS is a handsome volume well printed in large type and profusely illustrated with pictorial and other views. As the author remarks, it is "intended to deal solely with the nature and origin of the coast scenery", and we may add that a more appropriate general title would have been "The Coast Scenery of North Devon and parts of West Somerset and Cornwall". With many parts of this coast from Porlock to Clovelly and again at Bude and Boscastle geologists are familiar, but no one before has made such a careful detailed study of the entire coast, and in particular of the "wildest and grandest cliffs" that extend between Hartland Point and Bude.

The author in his Introduction gives a general account of the geology and main topographical features. In dealing with the scenery the lithological characters of the formations in the Devonian and Carboniferous systems and their structural features are of prime importance, but lists of fossils are recorded in the course of the work, and the aid of Mr. Henry Woods in the difficult matter of nomenclature is acknowledged in reference to the Devonian species. Attention is called to the disputed age of the Morte Slates, but the author "is inclined to hold, provisionally, to the older theory that

[1] =plate ii in Mr. Arber's book.

Synclinal Fold to the north of Bude, Hartland District: being plate ii of Mr. E. A. Newell Arber's book on *The Coast Scenery of North Devon* (reproduced by permission of the Publishers, Messrs. J. M. Dent and Sons, Ltd.).

[illegible]

the apparent sequence is the real succession", and in his map he places the Slates at the top of the Middle Devonian, above the Ilfracombe Beds. The great series of Culm Measures is divided into Lower and Upper Carboniferous. The latter group, as Mr. Arber demonstrated in 1904,[1] includes representatives of the Lower and Middle Coal-measures; while the Lower Carboniferous, in the Boscastle District, consists chiefly of "black shales, with subordinate bands of sandstone and occasional deposits of Radiolarian cherts". The junction on the coast between Lower and Upper Carboniferous north of Boscastle is regarded as a thrust-plane, and no section of the junction is visible on the northern side of the basin near Appledore.

Much yet remains to be done in working out the detailed succession of the Upper Carboniferous rocks, and this has not been attempted by the author. What is wanted now is a detailed section along the coast, and the author has paved the way for the accomplishment of this great task. His work will be an invaluable guide to all geologists and others desirous of investigating the coast sections. It would be appropriate as a prize in educational establishments.

Some parts of the coast can only be safely reached by boat; some cliff-paths are dangerous in windy weather, and a number of them are but little used. The author, however, gives clear directions with regard to the best way to get to each district, noting the most suitable head-quarters in it, together with particulars of 6 inch and other maps; he likewise recommends three golden rules: "First of all, study the length of beach to be traversed on a large-scale map, and also, if possible, from the cliff-top before the attempt is made. Secondly, make sure of the tides beforehand; and thirdly, never venture alone." Rock-climbers, as he remarks, will find in the roughest portions of this coast "a new paradise", for "No words can convey the wildness and grandeur of these cliffs".

With these and other preparations the reader is taken from Porlock to Boscastle in six stages, the districts being divided as follows: (1) Lynton, (2) Ilfracombe, (3) Mortehoe, (4) Clovelly, (5) Hartland, and (6) Boscastle.

The author points out and shows in his excellent plates that there are two distinct types of cliff—(1) that of the Hog's-back, rounded hills sloping steeply towards the sea with but low cliffs, and often wooded to near the sea-level, as at Porlock, Lynton, Heddon's Mouth, and Mortehoe; and (2) the flat-topped cliffs, with nearly vertical faces, as at Clovelly, Hartland, and Boscastle. These are alike spoken of as "sea escarpments", but it is usual to confine the term escarpment to inland features. It is true that the Hog's-back features are in the main formed by subaerial denudation, like the inland ranges of Exmoor, and have been undercut when brought under the action of the sea. On the other hand, the flat-topped cliffs "are the product of sea erosion on an elevated, flat, or gently sloping tableland", and have no connexion with subaerial escarpments.

With regard to the main outlines of the coast the author points out that there are no special reasons connected with exceptional hardness of the rocks to account for the headlands of the Foreland and of

[1] Phil. Trans., ser. B, vol. 197, p. 291.

Hartland Point; their forms are due rather to the topographical features of the land prior to the influence of the sea.

This was the view taken by Mr. Clement Reid in reference to Hartland Point in his Memorandum on the Coast Erosion of Cornwall and North Devon.[1] In fact, more information on sea-coast erosion has been published than the author appears to realize, from the time of De la Beche's *Geological Observer* to that of the *Sea-Coast* by Mr. W. H. Wheeler (1902), and the Reports of the Royal Commission on Coast Erosion, which contain a bibliography of the subject by Mr. Whitaker.

To the minor features along the coast, all of them full of interest and many of them never before described, the author has given special attention. From Hartland to Boscastle and in other tracts, where to judge from a small-scale map the indentations appear to be few, there are many small promontories and little bays, some caused by the relative hardness of the rocks, some by master-joints, faults, and thrusts, aided by streams. The dislocations and contortions in the Culm Measures are extraordinary in their abundance and variety, and many striking pictures and diagrams are given by the author. Plate ii—our Plate XVII[2]—which we reproduce by the courtesy of the Publishers, represents some of the bolder features. Nor has it been easy to get photographs on a coast where the difficulties of access are great and the breadth of shore but little: here the author expresses his obligations to Mr. D. G. Lillie, who contributes a sketch-map of the drainage of the country, and specially aided the author in his observations on the waterfalls.

No less than seventy-seven streams, flowing to the coast mostly from short distances inland, are shown on the map. "While the larger streams and rivers have been able to work faster at lowering the inclination of their valleys at their mouths than the marine erosion has been able to cut back the cliff, yet the smaller streams, possessing less power of eroding their beds, have worked at a relatively slower rate than the sea, and consequently end in hanging waters or coastal falls." Waterfalls in all stages are thus to be observed, and the influence exerted by the local inclinations and flexures in the strata, the initiation of canyons, and the features in the streams that flow off the Hog's-backs and flat-topped hills all receive attention.

Reference is made to the Raised Beaches of Baggy Point and Saunton, to the later Submerged Forests of Porlock and Westward Ho!, and to the influence of the movements on the coast-line, on the one hand in the separation of the Woolacombe cliff-line from the sea, and on the other hand in the drowning of certain river-valleys. The author regards a sandy beach as "a sure sign of a senile wave platform". Perhaps it would have been better to say that "senile wave platforms" are characterized by sandy beaches, the instances given being at Woolacombe, Croyde, Widemouth, and Braunton Burrows, where the supply of new materials eroded from the cliffs has ceased.

[1] Appendix, No. xii, B, p. 170, Report Royal Commission on Coast Erosion, vol. i, pt. ii, 1907.

[2] Plate ii (our Plate XVII), "Synclinal Fold to the North of Bude, Hartland District" (p. 7).

The travelling of shingle and the influence of shingle in the destruction of the cliffs by the breakers are dealt with, but we question the statement (p. 199) that "the greatest amount of erosion is off the points, where not only the waves are largest, but their transported load of debris is heavier and more powerful as an erosive factor". The author remarks that there the water is deepest. Mr. Reid in his evidence given before the Royal Commission (before noted) explains that in the case of some Cornish headlands the points may remain after the harder rock, which was the cause of the headland, had disappeared, as such points descend into deep water, which in stormy times would not be charged with the sand and pebbles that occur in the bays. Nor can we agree with the author (p. 36) that the waters of the Bristol Channel "have naturally little power of erosion even in times of storm". A visit to the coast near Watchet would not support this view. Nevertheless, we may fully agree with him that along the hard rocky coasts which he describes the changes that have taken place "within the memory of the oldest generation" are for the most part inappreciable. If, however, the destruction along the coast is not so serious as that along the borders of our eastern counties, the infinite variety of rock-structures, the grand scenery described with enthusiasm by the author, and the various processes of erosion now in action, form a far more interesting field of study.

II.—Barrande's Silurian System of Bohemia.

Système Silurien du Centre de la Bohême. Par Joachim Barrande. 1e partie : Recherches Paléontologiques. Continuation éditée par le Musée Bohême. Vol. IV : Gastéropodes, par le Doct. Jaroslav Perner. Tome III. 1911. Traduit par A. S. Oudin. Pls. 176–247.

SOME account of the scope of this great work was given in the Geological Magazine for March, 1908, together with a brief abstract of the contents of the first two 'tomes', and an explanation of the difficulties encountered and so ably overcome by Dr. Perner.

Now we have tome iii before us, which maintains in every respect the high standard of its predecessors. Dr. Perner expected that in addition to the material on the Gasteropoda originally collected this volume would also have contained all that has since come to light on the subject, as well as descriptions of the organisms other than Gasteropoda figured on the plates. This he has, however, found impossible, hence there is still a supplement to follow.

Tome iii contains the descriptions of members of seven families, viz., the Capulidæ, Naticidæ, Horiostomidæ, Calyptræidæ, Siphonariidæ, Atlantidæ, and the Pterotracheidæ: numerous figures of these are now given in addition to those already published, as well as figures of some fifty forms previously described. It also comprises comprehensive and exhaustive tables showing the distribution of all the forms dealt with, together with remarks on their genetic affinities, the nature of the sediments in which they are embedded, and their representatives in other countries. Valuable Addenda and Corrigenda to the three 'tomes' are also given.

Considering the divergence of opinion among authors with regard to the relationship and classification of recent mollusca of which they have complete representatives, it is not surprising that they should differ when they are dealing with the imperfect remains of past ages. Thus palæontologists are at variance as to the genera they include in the Capulidæ, Cuv., as some of the forms referred to it approach the Naticidæ and others the Neritidæ. Perner places in that family the following six Bohemian genera, containing 188 species and extending from E–e 1, to G–g 3: *Platyceras*, Conrad; *Orthonychia*, Hall; *Platyostoma*, Conrad; *Strophostylus*, Hall; *Cirropsis*, Pern.; and *Naticonema*, Pern. Perner separates from the Tertiary and recent genus *Capulus*, Montf., Palæozoic forms greatly resembling it, and groups them in the genus *Platyceras*, Conrad (*Acroculia*, Phill.). This genus is limited to shells distinctly spirally coiled, while *Orthonychia*, Hall, is reserved for those forming a straight cone whose apex is simply or slightly curved on the same plane. The number of forms belonging to these two genera is immense; Barrande's MS. enumerates 400 species, which are represented on 150 plates, more than half the number of species intended for the three 'tomes' of vol. iv. Since his time specimens have accumulated, and in the midst of such wealth of material it has been difficult to decide on the limits of a species, for a considerable extent of variation exists on the one hand, while on the other there are strong connecting links. Though not reducing the number of species to such a degree as Lindström does for Gotlandic forms, Perner yet brings them down to 98 for *Platyceras*, of which 96 are new, and 45 for *Orthonychia*, of which 41 are new. There are besides numerous varieties and some doubtful species not included in the above numbers. *Platyceras* is most abundant in the Silurian (E), while the greater number of *Orthonychia* occur in the *Devonian* (F–f 2), generally in the condition of internal moulds. Dr. Perner finds it convenient to divide these two genera into groups of species, each associated with a characteristic form.

Naticonema, Pern., is distinguished by its flat, discoidal shape, without umbilicus, slightly thickened inner lip with thin, vertical lamella, and by its longitudinal prominent scaly striæ. *N. similare*, Barr., the only Bohemian species, is the genotype. It comprises, in addition to his *Otospira squamata*,[1] shells referred by Barrande to no less than seven different species belonging to six distinct genera. Amongst foreign forms Dr. Perner would place in this genus some specimens figured by Lindström as *Platyceras cornutum*. His *Naticonema* is confined to E–e 2.

Cirropsis, Pern., comprises more elongated shells with the general appearance of *Holopea*. They are distinguished by their loosely coiled whorls, oblique and unthickened aperture, and by the direction and nature of their transverse ornamentation. Numerous species were described by Barrande in MS., and referred by him to *Cirrus*. These are reduced by Perner to five, and are shown to differ from *Cirrus* in the form of the aperture and ornamentation. This genus occurs in E–e 1, and e 2 (Sil.), and is represented both in Gotland and America.

[1] Spelt by Perner *squammata*.

Perner prefers retaining the name *Platyostoma*, Conrad, to adopting Fischer's *Diaphorostoma*, which he suggested on account of the name *Platystoma* having been previously used, and he considers the difference in spelling sufficient distinction without reference to the derivation of the word. The seven species included in this genus were with one exception (*P. ferrigenum*, Pern.) described by Barrande, and were generally placed by him in *Natica* or *Naticella*. This has the widest range in time of any of the genera of the Capulidæ, occurring in D–d 4, E–e 2, and G–g 1.

Five species are referred to *Strophostylus*, Hall, all but one of which were previously included in *Natica* or *Prænatica* by Barrande. The genus certainly bears a superficial resemblance to *Natica*, while on the other hand it has features in common with *Platyceras*. *S. gregarius*, Barr., the first species quoted, is shown to be very variable, and to comprise several forms considered distinct species by other authors, but regarded by Dr. Perner merely as well-marked varieties, with numerous intermediate links, of which an ample series of figures is given. These species occur in E–e 1, F–f 1, f 2, and G–g 1.

The relationship of some of the members of the Naticidæ, Forbes, is not altogether clear. Some authors would place *Strophostylus* and *Platyostoma* here, but Perner, as already shown, considers these genera more closely allied to the Capulidæ. In the Naticidæ he places *Naticella*, Münster, the new genera *Himantonia*, Pern., and *Prosigaretus*, Pern., as well as the sinistral *Scævogyra*, Whitfield, with its new sub-genus *Versispira*, Pern., and the new genera *Læogyra*, Pern., and *Antispira*, Pern.

A new sub-genus, *Naticellina*, Pern., is suggested for a species resembling *Naticella* in the character of the aperture, but differing in its form and spiral ornamentation, which are more like *Vanicoro*, Quoy & Gaimard. *N. suavis*, Barr., from E–e 2 is the genotype.

Himantonia, Pern., is represented by two species whose imperfect state of preservation does not admit of a diagnosis sufficiently well-defined to associate any foreign form with them, though the characters observable show them to be distinct from the members of any previously described genera. In ornamentation they resemble *Prosigaretus*, but their shape is distinct. The genotype is *H. amœna*, Barr. Both species occur in F–f 2.

Prosigaretus, Pern., resembles the Tertiary and recent *Sigaretus* in the form of the mouth, but differs in being ornamented with undulating and ramified grooves. The only species, *P. perornatus*, Barr., is the genotype, and it is represented by one imperfect specimen from F–f 1.

Versispira, Pern., is given as a sub-genus of *Scævogyra*, Whitf., from which it is distinguished by the section of the whorls being reniform instead of sub-triangular, and the aperture is probably of different shape. There are four species.

Læogyra, Pern., is also sinistral, and possesses rounded, flattened whorls having an elliptical section and ornamentation consisting of strong transverse ribs. There is but one specimen known.

Antispira, Pern., the other sinistral genus, is proposed for a single badly preserved specimen with the general form of the Naticidæ.

It has, however, very distinctive ornamentation, consisting of strong transverse ridges crossed obliquely by spiral ones, which give rise to oblong tubercles at the points of crossing. All the species of the last three genera are from Étage D (Ordovician).

In the family Horiostomidæ, Koken, there are recorded four genera, *Horiostoma*, Mun.-Chalm., *Tubina*, Barr., *Meandrella*, Pern., and *Spirina*, Kayser. The genus *Horiostoma* is separated from *Poleumita*, Clarke (*Polytropis*, De Kon.), with which it has generally been identified, and is distinguished by having the umbilicus surrounded by a keel, by the rapid increase of the whorls, by the last one being often free, and by its trapezoidal aperture without operculum. It is represented by two species.

Tubina, Barr., is closely related to *Horiostoma*, and is chiefly distinguished by having the aperture enlarged like a trumpet, and by being symmetrically coiled. Three species are described.

Meandrella is created for a species (*Euomphalus sculptus*, Quenst.) greatly resembling *Tubina*, but differing in the ornamentation being less developed, in having zigzag transverse lines and in having the aperture less enlarged. The species belonging to the last three genera occur in F–f 2.

The fourteen species of *Spirina* described are all confined to Étage E–e 1, and e 2, with the exception of one which is also represented in F–f 1.

The family Calyptræidæ, Koken, in addition to the genus *Clisospira*, Billings, comprises two new genera of Perner, *Paragalerus* and *Procrucibulum*. The former is represented by a single species and greatly resembles *Progalerus*, Holzapfel, but is distinguished by its convex whorls, deep sutures, and ornamentation.

Procrucibulum contains three species, having a likeness to the genus *Crucibulum*, Schumacher, but which differ in the length and in the spiral form of their lamellæ.

We now come to the description of the genus *Hercynella*, Kayser (*Pilidion*, Barr. MS.), whose affinities have given rise to considerable diversity of opinion, authors referring it respectively to the Siphonariidæ, Fissurellidæ, Auriculidæ, or the Capulidæ. The chief requisite for deciding this question is the discovery of well-defined muscular impressions, and hitherto little of this nature has been observed by Dr. Perner. He places *Hercynella* in the first-named family, though its habits, according to him, must have been very different from other members of the group. It is especially characteristic of F–f 1, where it is represented by eight species. He states that the argillaceous and calcareous schists in which it occurs were deposited in warm seas of little or medium depth, and that they were certainly not of littoral origin. On this supposition, and taking also into account the thinness of the test, he suggests that it lived a pelagic life. As evidence in favour of its being a pulmonate he quotes that the fold of the shell varies in position in the same species, being sometimes dextral and at others sinistral, and he compares this with the case of certain species of *Helix* which may be either dextrally or sinistrally coiled.

Now the recent *Siphonaria* and its near ally, *Gadinia*, are eminently sedentary, being attached to rocks in the littoral zone, the former at or above high-water mark, and the latter in the zone between high and low water. Their characters are generally regarded as transitional, and many authors would place them in the Opisthobranchiata rather than in the Pulmonata. A full consideration of all the circumstances renders it probable that the true relationship of *Hercynella* should be sought elsewhere. Dr. Perner divides them into two groups, one having low shells with a wide and but slightly raised fold, the other composed of conical forms with a very prominent fold. Fifteen species are recorded ranging from E–e 2, to G–g 3.

The last order to be treated is the Heteropoda, Lam., to which Dr. Perner refers two genera, *Porcellia*, Léveillé, and *Procarinaria*, gen. nov.; the former to the family Atlantidæ, and the latter to the Pterotracheidæ. He enters into minute particulars about the structure of *Porcellia*, and gives his reasons for differing from other authors in the position he assigns it. It is represented by six species, all from E–e 2, with the exception of *P. aberrans*, Koken (*P. bohemica*, Barr. MS.), which is from F–f 2.

Procarinaria is created by Dr. Perner for the reception of a single species from E–e 1. It is distinguished by a very small, compressed shell whose aperture is slightly notched in the middle, and the keel is solid and narrow.

The description of species being thus completed, tables giving their ranges follow.

In Table i we have the genera arranged *alphabetically*, with their synonymy, the species they comprise, their vertical distribution, and references to their descriptions and figures.

Table ii shows the vertical distribution of the genera arranged *zoologically*, with the number of species and particulars about their recurrence.

Table iii contains the genera arranged alphabetically, with their horizons and number of species.

Table iv gives similar information for the families.

Table v enumerates the genera and species occurring in each 'Bande' into which the 'Étages' are subdivided.

The author's critical analysis of these tables gives the general results of his long labours and merits the closest attention. The total number of species recorded is 719, of which 41 recur at different horizons, they are comprised in 157 genera and 22 families. As might be expected, the smallest number occurs in C (Cambrian), there being but one family, the Patellidæ, with one genus containing two species. There is a considerable increase in Étage D, which has 29 genera comprising 69 species.

E–e 2 contains the greatest number of species, viz. 406 referable to 103 genera.

E–e 1 has only 97 species included in 23 genera.

F–f 1 shows a still further decrease, having only 11 genera containing 16 species.

F–f 2 comes next to E–e 2 in numbers, having 147 species in 64 genera.

In G the amount of Gasteropoda decreases greatly, so that there are only 13 genera with 19 species.

With regard to duration Dr. Perner divides the genera into two series, viz.:—

A. Those which are confined to only one 'bande', of which there are 95.

B. Those which exist in more than two contiguous 'bandes', whose number is only 7.

Ten genera are more especially remarkable for their longevity, viz., *Carinariopsis*, *Clisospira*, *Cyrtolites*, *Euryzone*, *Hercynella*, *Palæacmæa*, *Loxonema*, *Platyostoma*, *Turbonitella*, and *Ectomaria*. The four genera *Bembexia*, *Calloconus*, *Mourlonia*, and *Trochonema* are peculiar for their manner of reappearing after long periods of absence. This is an instructive instance of the imperfection of the record.

E–e 1, and e 2, are especially closely connected, having nineteen genera in common; but there is an appreciable break between e 1 and D, for they have only one genus in common. There is also a decided break between F–f 1 and f 2, which is both palæontological and petrographical; only five genera are common to both divisions. F–f 1 is very poor in fossils, while f 2 is remarkably rich and has thirty-four genera in common with E–e 2. G–g 1 has only seven genera in common with F–f 2.

The nature of the matrix is in a great measure accountable for the abundance of fossils in E–e 2 and F–f 2, as the rock is for the most part calcareous.

The greater number of species also occur in a single 'bande', there being but thirty-nine species common to two contiguous 'bandes' (E–e 1, and e 2), and only two species appearing in both E–e 2 and F–f 2. The reappearance of species in succeeding 'bandes' only attains about 6 per cent. of the total number of species, and most of these are confined to E–e 1, e 2, and F–f 1 (Sil.).

Thus, owing to their less frequent recurrence, Dr. Perner regards the Bohemian Gasteropoda as of even greater service in the determination of the age of horizons than the Trilobites, Cephalopods, and Brachiopods.

A chapter is devoted to genetic relationships, but Dr. Perner does not consider our knowledge of genera, especially of those from foreign localities, sufficient for accurate deductions.

A list of twenty-nine species common to Bohemia and other countries is given, but this likewise cannot be looked upon as absolutely correct on account of the imperfection of the figures and descriptions hitherto published in most countries. Only four—two Silurian and two Devonian—are identified with British species, and it is very doubtful if the two former are conspecific.

Dr. Perner also gives a table of species from other countries, greatly resembling, though not identical with, Bohemian ones.

The immense importance of the work seems to justify the details entered into here, which, after all, give but a mere outline, the limits of space rendering it impossible to give more. The value of such a treatise to students of Palæozoic palæontology is apparent, and they must all feel deeply indebted to Dr. Perner for this painstaking and laborious contribution to science.

JANE LONGSTAFF (DONALD).

III.—Royal Commission on Coast Erosion and Afforestation.

Third (and Final) Report of the Royal Commission appointed to inquire into and report upon certain questions affecting Coast Erosion, the Reclamation of Tidal Lands, and Afforestation in the United Kingdom. 1911. Price 3*s*.

In the Geological Magazine for January, 1908 (p. 34), we drew attention to the First Report, and accompanying Minutes of Evidence, of this Royal Commission. The terms of reference of the Commission were afterwards extended to take in Afforestation, and the Second Report, dealing with that subject, was published in 1909. It includes a short account of the nature and extent of land suitable for sylviculture, and deals more particularly with methods of culture, labour, and administration; the Commission consider "that there are roughly 9,000,000 acres of land in the United Kingdom which may with advantage to the State be afforested".

The Third Report gives a summary of the evidence to which we referred in our former article, together with the principal conclusions and recommendations. The changes in the relative level of land and sea are first dealt with, and to the question "whether movements of a similar nature are likely to recur, and if so, when", it is remarked that no answer can be given. Mention, however, is made of slight submergences possibly in progress on the Northumberland coast, in the north of Scotland, and on the south and west of Ireland. The amount of erosion and accretion along the coasts is considered. It is admitted that erosion takes place below sea-level, and that "fine gravel had been found in suspension in the English Channel at 4 fathoms above the sea-bed in a depth of 37 fathoms"; but to what depth the movement of detritus on the sea-floor is effective in eroding is a question "on which further investigation is needed". The accumulation of shingle at Dungeness (the largest in the kingdom) is attributed to the supply of pebbles from the Sussex coast to the westward, "the shingle having travelled along the shore and down to the level where the waves influence the travel in deep water."

There is much valuable information about the derivation and distribution of beach deposits, and it is remarked "that while the beach material should not be removed from any part of the coast where it acts as a protective agency, erosion must continue at some places in order that a supply of fresh material may be furnished to replace that which is ultimately worn away".

Descriptions are given of the reclamation of alluvial flats and salt-marshes, of the protection afforded by Blown Sands, and of the aid given by various plants in the accretion of mud-flats and in the checking of wind-drifted material. There is an excellent description of the main geological features of the British coast-lines, and this is followed by an account of the erosion and accretion that is taking place. The general results are that while "on the one hand considerable areas of agricultural land are lost, sea-coast towns are injured, and harbours tend to silt up, on the other, large areas of valuable agricultural land are gained, and these areas on the average are more valuable than those which are lost". The gain has been almost entirely in tidal estuaries, the loss on the open coast. In most cases the provision to protect agricultural land bordered by sea-cliffs that are formed of easily eroded strata "would involve a cost far in excess of the value of the land". Along some parts of the eastern coast, notably in Suffolk, the erosion has been intermittent, intervals of a series of years attended by little or no encroachment having occurred. The condition of Southwold, which has suffered grievously, has during the past few years improved by the construction of a north pier and by a harbour of refuge, so that the beach deposits are accumulating.

Descriptions are given of various engineering works for the protection of coasts, and recommendations are made with regard to the control of the foreshore, it being held "that a clear right of passage by foot upon all foreshores in the United Kingdom, whether Crown property or not, should be conferred upon the public". Recommendations are also made with regard to the further areas that might be reclaimed, and to loans of money for sea-defence purposes; but the Commissioners do not support the contention that sea-defence is a national service.

H. B. W.

IV.—Geology and Agriculture.

A Report on the Agriculture and Soils of Kent, Surrey, and Sussex. By A. D. Hall, M.A., F.R.S., Director of the Rothamsted Experimental Station, and E. J. Russell, D.Sc. Published by the Board of Agriculture and Fisheries, London. 8vo, cloth; pp. viii, 206, with 56 illustrations. Price 2*s*. 6*d*.

NINE years ago there was published a First Report on the Soils of Kent and Surrey, by Mr. Hall, who was then Principal of the South-Eastern Agricultural College, Wye, and Mr. F. J. Plymen. The main results at that time achieved are embodied with certain necessary revisions, and with an account of the soils and agriculture of Sussex; and the treatment of the whole subject, or series of subjects, is amplified and presented in a masterly manner in the volume before us.

To the geologist the Report is of exceptional interest, and it may be safely regarded as the most important volume published in this country on the bearing of geological science on agriculture. Half a century ago the practical advantages of a knowledge of geology to the farmer were not so apparent as they now are. Indeed, they were not to be discerned in many areas, for as S. V. Wood, jun., remarked in 1865, in reference to the eastern and midland areas, the observer was "often baffled by the highly fictitious representation given in every Geological Map". The fact is the Glacial Drifts, which may be from a few feet to more than 200 feet in thickness, were omitted from the maps, and they were not only useless but misleading from an agricultural point of view.

Since that date the Geological Survey has recognized the importance of mapping all the superficial deposits, and the surveys of the subsoils, which have been made on the 6 inch scale, form a sound basis for the more detailed agricultural investigation of the soils. Unfortunately the geological maps of large areas of England, notably in the counties of Gloucester, Hereford, Shropshire, Worcester, and Warwick, remain in the 'fictitious' condition.

In the First Report, before mentioned, it was stated that "The geological map of the country furnishes the only possible basis for a classification and survey of its soils, at any rate, as far as the preliminary work goes". In the present work Mr. Hall observes (p. iv), "It will be seen that we have taken the geological formations as the basis of our work, and have assumed that each formation represented in the district will give rise to a soil-type which can be characterised both by its mechanical analysis and by special features in the farming which prevails over its outcrop. The justification for these cardinal assumptions was obtained in the early stages of the work by following the dividing line representing the outcrop of two formations, and finding (1) that the dividing line held for the soils as well as for the underlying formations; (2) that the soils from any formation (with one or two exceptions) did show on analysis certain common features which marked them off from other soils. These conclusions have been strengthened as our work proceeded; all our experience in the field goes to show that each formation in the area under consideration gives rise to a distinct soil-type, the characteristic composition of which can further be recognised by making up an average from the mechanical analyses of the samples taken from that formation."

Allowances, of course, have to be made in all cases for wind-drifted or other adventitious material in the soil, and for downwash on slopes. The above quotation, however, shows the importance of a careful detailed geological (or subsoil) survey.

The Geological Survey has indeed done more for the district than Mr. Hall appears to know, as new series 1 inch Drift maps, Nos. 317 (Chichester and Midhurst), 332 (Bognor, Selsey, and Littlehampton), 333 (Worthing and Rottingdean), and 334 (Newhaven and Eastbourne), have been published, and manuscript copies of 6 inch maps of the areas have been deposited for public reference in the Library of the Museum of Practical Geology.

It is therefore all the more remarkable that the results obtained by careful soil-investigation over areas represented for the most part by the older Drift maps of the Geological Survey have led to conclusions which we are justified in considering as far-reaching.

Similar results were notified in the Vale of Belvoir and bordering tracts by Mr. G. W. Lamplugh,[1] who had the advantage of some discussion on the ground with Mr. Hall and Professor T. H. Middleton. There it was found that "The geological boundaries conform fairly well to the varied character of the soils and subsoils, though the margins of the superficial deposits are rarely so sharply defined as the lines necessarily drawn for their delimitation on the map might seem to imply". We have dwelt at length on these matters because it may now be considered as demonstrated that a careful detailed geological map of all the exposed formations (Drift and Solid) is of essential service to the agriculturist.

[1] *Geology of the Melton Mowbray District, etc.* (Mem. Geol. Surv., 1909), p. 99.

The volume before us is divided into six chapters, dealing with the Natural Features; Agriculture; Soils on different formations, with methods of analysis; Relation of Soils to Crops; Building Stones and other Economic Products; and Analyses of Soils. There is also a bibliography and capital index. The illustrations are numerous and include orographic and geological maps, map of rainfall, maps showing the distribution of arable, grass, and wood lands, of crops (cereals, roots, hops, fruit, etc.), and of the distribution of cattle. There are pictorial views of the features of the Wealden, Lower Greensand, Chalk, and other formations, and Romney Marsh. There are pictures of oxen, sheep, and pigs, of hop-kilns, and of charcoal-burning. The illustrations, indeed, give an idea of the many subjects discussed, and of topics that will interest not only landowners and farmers, but geologists, geographers, and general readers, for there are many historical references to the state of the country in old times.

H. B. W.

V.—Brief Notices.

1. Cambrian Geology and Palæontology.—Dr. C. D. Walcott continues the publication of his researches on these subjects (Smithsonian Misc. Collections, vol. lvii, Nos. 2, 3, and 4, 1911). In No. 2 he deals with the "Middle Cambrian Merostomata", describing a new sub-order of the Eurypterida, to which he gives the name Limulava; a new family Sidneyidæ, and a new genus *Sidneyia* named after his son Sidney S. Walcott, who discovered the type-specimens in the Stephen formation in British Columbia. The species is named *S. inexpectans*. Another new genus from the same locality and horizon is named after Dr. H. M. Ami, *Amiella ornata*, and it is remarked that a second species of this genus or a closely allied form occurs in the Lower Cambrian of Yunnan in Indo-China.

In No. 3 Dr. Walcott describes certain "Middle Cambrian Holothurians and Medusæ", and in No. 4 he describes some Cambrian Brachiopods, Mollusca, and Trilobites from China, being his third preliminary contribution on the "Cambrian Faunas of China". It is anticipated that the full memoir on the subject will be published this year.

2. Moldavites or Tektites.—In a paper "On the supposed origin of the Moldavites and like sporadic glasses from various sources" (Proc. U.S. Nat. Museum, vol. xl, p. 481, 1911) Mr. G. P. Merrill considers that there is no proof that the specimens, which Suess has included under the name 'tektites', had a cosmic origin. He observes that "Whatever may have been their original source, the Bohemian and Moravian specimens are now simply water-worn pebbles of weathered glass, originally etched by corroding vapours or solutions, the results being indistinguishable from those produced by artificial etchings on obsidian with fluorhydric acid".

3. Lessons on Soil. By E. J. Russell, D.Sc. (1911, pp. xv, 132; price 1*s.* 6*d.*).—This is the first volume of a "Nature Study Series" in course of publication by the Cambridge University Press. It is an elementary work, admirably clear and concise, the main object of

which is to teach the composition and characters of soils and subsoils by means of practical experiments. A list of necessary apparatus is given, and the materials for examination should as far as possible be obtained locally. The experiments are adapted to explain porosity and permeability, the formation of springs, the shrinkage and expansion of clay, the action of lime on certain soils, the temperature of the soil, and the food and growth of plants. The origin of soils in general, of leaf-mould and peat, the action of worms and micro-organisms are discussed, and observations are made on tillage and drainage, on the aspect of the land and the influence of man. It might be mentioned (p. 1) that ground that is hard in dry weather and sticky in wet weather is not necessarily clay, as such conditions may be found on Chalk tracts. Reference is made (p. 22) to "the foolish man who built his house upon sand"; but this is rightly qualified (pp. 24 and 30) inasmuch as "people prefer to live on a sandy soil rather than on a clay", and the desirable conditions are shown in diagram (fig. 17). The view of "Landslip *in the Isle of Wight*" (fig. 6) should be "at Lyme Regis".

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

June 14, 1911.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communications were read:—

1. "On a Monchiquite Intrusion in the Old Red Sandstone of Monmouthshire." By Professor William S. Boulton, B.Sc., Assoc.R.S.C., F.G.S.

The paper describes a hitherto unrecorded monchiquite, intruded into the Upper Old Red formation of Monmouthshire, about midway between Chepstow and Usk. The precise manner of its intrusion is doubtful; reasons are given for regarding it either as a dyke with a north-westerly trend or as a volcanic plug (bysmalith). The disturbance and metamorphism of the contact-rocks (seen only at its eastern edge) are dealt with, as also the rounded lumps of marl and subangular blocks and chips of sandstone incorporated in the igneous rock.

The monchiquite, which is described in detail, contains unusually large phenocrysts (measuring up to 5 and 6 inches) of augite (chrome-diopside) and biotite, generally much corroded. Rounded lumps or 'nodules' of olivine-augite rock with chromite are also included, the olivine now being represented by secondary products, including iddingsite. A second generation of purple idiomorphic augite, biotite, and decomposed olivine occurs porphyritically in the ground-mass, with occasional granules of quartz and chromite.

The ground-mass is a felt of minute elongated augite prisms, magnetite grains, and flakes of biotite, and the remaining space is occupied by analcite enclosing apatite needles. Reasons are adduced for regarding the analcite of the ground-mass as primary. Ocelli filled with secondary carbonate, chlorite, analcite, etc., are common.

A complete analysis of the rock is given, which bears out the petrographical evidence that it is a very basic lamprophyre belonging to the monchiquite group. It is compared with other rocks of the group, and in particular with the monchiquites and camptonites of Colonsay, with which it has many points in common. Finally, its age and possible connexion with the only other known intrusion into the Old Red Sandstone of the South Wales area—that of Bartestree, near Hereford—are referred to.

2. "Notes on the Culm of South Devon: Part I—Exeter District." By Frederick George Collins, F.G.S.; with a Report on the Plant-remains by E. A. Newell Arber, M.A., F.G.S., and Notes on the Cephalopoda, by George C. Crick, Assoc.R.S.M., F.G.S.

The object of this paper is to show that the fauna of the Culm Measures of South Devon proves these beds to be the equivalents of the Pendleside Series of the Midlands, as has been shown by Dr. Wheelton Hind to be the case with the Culm Measures of North Devon. The area from which these fossils have come may be roughly described as a narrow strip of country 17 miles long, running from south-west to north-east, having the city of Exeter as its centre. The work has extended over ten years, and innumerable sections have been examined without result. The actual fossiliferous localities are eighteen in number, but often the fossils are too poor for determination. Plant-remains are abundant, but determinable specimens very rare; the preservation of the fragments is often excellent, although the fragments themselves are insufficient for specific determination. Such fossils as have been determined show a sequence from below upwards as we go from south to north; but it seems advisable to seek more evidence, and an attempt will be made by working due north from Waddon Barton, a point farther to the west, when, if the attempt is successful, another communication will be offered to the Society.

II.—Linnean Society.

June 1, 1911.—Dr. D. H. Scott, F.R.S., President, in the Chair.

Dr. A. Smith Woodward, F.R.S., read a paper on "The Fauna of the Carboniferous Period, so far as it has been discovered in the same deposits as the Carboniferous flora".

The fauna agrees with the flora in consisting, for the most part, of highly specialized representatives of the lower groups, but is singularly modern in some respects. Some of the freshwater and land mollusca are scarcely distinguishable from genera still existing. All the Crustaceans are of primitive groups, and some of the most interesting are related to *Anaspides*, which still survives in Tasmania. The myriapods, scorpions, and spiders are similar to those of later date, but a few of the scorpions retain obvious remnants of the characters of their aquatic ancestors. Limuloids also occur. Insects are numerous, but all belong to the lower groups in which there is no complete metamorphosis, and there are many generalized types which can scarcely be referred to existing orders. Cockroaches are numerous, but have transparent fore-wings. Primitive dragon-flies occur, and some of these are the largest known insects, with a span of wings measuring 2 feet. Among fishes, the spiny acanthodian sharks, which are typically Lower Palæozoic, are still found in the Carboniferous fauna, and are known to have been preyed upon by the higher fishes. The pleuracanth sharks are characteristic of the period, and interesting as showing a more generalized vertebrate skeleton than any later fishes. The cochliodont sharks with grinding teeth appear to be closely related to the existing *Cestracion*, but have many of the teeth fused into extensive plates. Some of the sharp-toothed sharks also seem to have had their teeth fused into rigid masses. The highest fishes are the palæoniscids and platysomids, which exhibit all the fundamental characters of the present-day sturgeons, obscured beneath a normal covering of ganoid head-plates and scales. Large dipnoan fishes are numerous, and differ little from *Ceratodus*, except in showing traces of the separate points of which their dental plates are composed. Most important are the crossopterygian fishes, of which *Rhizodus* and *Megalichthys* are typical genera. These fishes make a closer approach to the earliest lung-breathers than any fishes which have existed before or since. Lung-breathers were certainly in existence just before the beginning of the Carboniferous period, and all seem to belong to a very primitive group of Amphibia, variously termed Stegocephalia or Labyrinthodontia in allusion to the complete roofing of their cheeks by bone and to the complicated structure of their teeth. In their possession of supra-temporal plates and often of post-temporal bones, as also in the marking of their superficial bones by the course of the slime-canals, these amphibians more closely resemble fishes than any later members of the order. Towards the end of the Carboniferous period some of the smaller Stegocephalia, the so-called Microsauria, seem to have passed into true reptiles very similar to the surviving *Sphenodon* or *Hatteria*.

III.—The South Staffordshire and Warwickshire Institute of Mining Engineers.

At the meeting on June 12, 1911, at the Council House, Walsall, a paper "On the Carboniferous Limestone of Fair Oak, Cannock Chase Coalfield", was read by Mr. George M. Cockin.

The rocks underlying the Coal-measures of the Cannock Chase Coalfield have been described as being Silurian Limestone. The condition existing at Walsall, where the Silurian rocks may be seen immediately below the Coal-measures, was supposed to continue further north, and this was said to be the case at a bore-hole at No. 2 Pit, Cannock Chase Collieries.

A few years ago fresh light was thrown upon the subject by the discovery of fossils belonging to the Lower Carboniferous or Mountain Limestone upon the old spoil-heaps of No. 1 Trial Pit, Fair Oak Colliery. The discovery formed the subject of a paper read before the Geological Society of London in 1906.[1]

A number of new fossils have been found since that date, and it is

[1] "On the Occurrence of Limestone of the Lower Carboniferous Series in the Cannock Chase portion of the South Staffordshire Coalfield," by George Marmaduke Cockin, Quart. Jour. Geol. Soc., vol. lxii, p. 523, 1906.

chiefly with the object of having a complete list of these published that the present paper is written.

The fossils have been named by Dr. Wheelton Hind, F.G.S., and Dr. Arthur Vaughan, F.G.S. Both these geologists have made a special study of the Lower Carboniferous Limestone, the former having established the position of an important group of rocks occurring at the very top of the series, and named by him the "Pendleside Rocks"; while to Dr. Vaughan is due the systematic grouping into definite zones of the whole of the Lower Carboniferous Limestone rocks. Dr. Vaughan based his work upon a thorough exploration of the fossils contained in the well-known section in the Avon Gorge, near Bristol, the result being a complete chart of the whole series, named the "Avonian Sequence". By means of this chart any collection of fossils belonging to the Lower Carboniferous may be recognized, and their particular position may be assigned in that sequence.

Dr. Vaughan, who examined the fossils found at Fair Oak, had referred them to the top of the Avonian fauna. The following is a list of the fossils determined:—

BRACHIOPODA.

Athyris planosulcata, Phil.
Chonetes laguessiana, de Kon.
Ch. gibberula, M'Coy.
Ch. sp.
Orthotetes crenistria, Phil.
Productus giganteus, Martin.
P. longispinus, Sow.
P. punctatus, Martin.
P. semireticulatus, Martin.
P. hemisphericus (senile form), J. de Sow.
Reticularis lineata.
Rhipidomella michelini, Léveillé.
Rh. divaricata, M'Coy.
Seminula ambigua, Sow.
Spirifer planicostatus, M'Coy.
Spiriferina cristata, Schlotheim.
Sp. minima, Sow.
Schizophoria sp.

CEPHALOPODA.

A fragment.

CORALS.

Amplexi zaphrentis, Vaughan.
Millepora rhombifera, Phil.

CRINOIDEA.

Stem-joints.

GASTEROPODA.

Platyschisma.

ECHINOIDEA.

Archæocidaris urei, Fleming.

LAMELLIBRANCHIATA.

Parallelodon sp.

FISH-REMAINS.

Scales and teeth.

The trial-shaft at No. 1 Fair Oak commenced in January, 1872, passed through 286 feet of Bunter Sandstones and Gravels, set in an excessively hard calcareous conglomerate.

A remarkable feature in these beds was the occurrence of copper- and lead-ores in considerable quantities. These ores are, the writer believes, common enough in Keuper Sandstones, but are rarely met with in Bunter Conglomerates.

At a depth of 29 feet from the surface lead-ore occurred in large quantities, disseminated freely among the gravel, and continued down to a depth of 85 feet. At a depth of 75 feet from the surface copper-ore first showed itself, quite separate from the lead.[1] Lower down both ores were found mixed together in large quantities. At the base

[1] See "Copper and Lead Ores in the Bunter", by W. Molyneux, GEOL. MAG., Vol. X, No. 1, 1873.

of the conglomerates 750 gallons per minute of water were tubbed back. Passing through a thick bed of Red Marls, with hæmatite nodules, the shaft was continued down through shales, sandstones, ironstone bands, and clays to a depth of 813 feet, but no workable seam of coal was found. Below this a bore-hole $1\frac{7}{8}$ inches in diameter was continued in Coal-measure shales and sandstones to a depth of 975 feet. A feeder of salt water was met with at 960 feet, and a little lower a feeder of fresh water, together amounting to about 70 gallons per minute.[1]

Before abandoning the undertaking it was decided to search for coal by driving headings in the Coal-measures. Accordingly, at some distance above the bottom of the shaft, a heading was driven for 44 yards on the full dip of the measures, and from it headings were driven for nearly 150 yards at right angles on the strike. All operations were suspended on December 1, 1875, four years from the commencement.

It must have been in one of the exploring headings that the Carboniferous Limestone was found, because its position on the spoil-bank shows it to have been the last material deposited there before the place was abandoned.

After having lain undisturbed and exposed to the elements for nearly forty years, it was discovered by Mr. George Wetherall, of Rugeley, seven years ago, and he with the writer made a thorough search, with the results now described. The limestone lying exposed for so long a time has weathered away, and left the fossils very clearly defined. In no instance is there any appearance of the limestone being water-worn, and those pieces which were covered up have all the appearance of having been blasted out of the mine.

The section of strata passed through explains why the search for coal at this spot ended in failure; indeed, it would be difficult to find a better illustration than this affords of the immense amount of denudation to which the Coal-measures were subject, either previous to or at the time when the Bunter Conglomerates were laid down.

The marls and clays of Cannock and Wimblebury, etc., indicate that originally the Upper Coal-measures were present over some portion, at any rate, of the coalfield. Not only, however, have nearly all traces of these Upper Coal-measures been lost, but the productive Coal-measures themselves have in places been almost entirely removed.

It is quite certain that from whatever direction the great water-borne mass of conglomerate came in Triassic times, the coalfield on which it rested was of very irregular shape. The Fair Oak trial-pit proves that at that spot all the Coal-measures to an horizon below the Deep Coal Seam were denuded.

The area of this denudation is not of large extent: its limit on the south was proved by an exploring heading driven from a shaft sunk by the South Staffordshire Waterworks Company, while on the north-east the shallow coal-workings in Brereton Coppice Colliery have proved the position for an extent of over 1,000 yards.

The 'wash-out', as it is locally called, probably owes its existence

[1] See *Mining Journal*, p. 192, 1876.

to an anticlinal elevation, and while this elevated mass caused an obstacle which was no barrier to the mighty flood that removed it, it at the same time caused the limestone to be raised up to the position that it now occupies. The occurrence of the limestone must owe its existence either to a rapid thinning out of the lower beds of the Coal-measures or to its having been raised in the way suggested.

The great Carboniferous Limestone formation of Derbyshire probably thins out gradually southwards, until only a few feet of the upper beds are left. To quote Professor Bonney, in his remarks on the Fair Oak Limestone—

"About 22 miles to the east, the Carboniferous Limestone appeared to thin out on the north side of Charnwood Forest; it was doing the same thing near Wellington, about 47 miles to the west . . . over a semicircular district of which Fair Oak was the centre. He thought that the discovery marked a point in the southern shore-line of the northern sea-basin, perhaps a bay: thus resembling the limestone on the Titterstone Clee Hills, which must occupy a similar position on the northern shore-line of the southern basin."[1]

The collection of Carboniferous Limestone fossils from this pit were then handed over by Messrs. Cockin and Wetherall to the Institute for preservation and future reference.

MISCELLANEOUS.

British Museum (Natural History) Department of Geology.

Cainozoic Freshwater and Lacustrine Mollusca from Germany.—The extraordinary richness of the collections of the British Museum has rarely been better illustrated than by the table-case of German Cainozoic Mollusca just arranged and exhibited in the Geological Department by Mr. R. B. Newton with the assistance of Mr. G. K. Gude. The accumulation of nearly a hundred years, we have a fine series of the land, freshwater, and lacustrine shells which lived in Germany from Oligocene to Post-Pliocene times exhibited to our notice for the first time. No such series is to be found in any Continental museum with which we are acquainted. Many of the specimens come from localities now closed or inaccessible, and such well-known places as Cannstadt, Heinheim, Oeningen, Mosbach, Budenheim, Floersheim, Mainz, Wangen, Weimar, Taubach, Hochheim, Wiesbaden, and a score of others are represented in the collection. Similar series of Mollusca from the other Continental areas are in course of arrangement, the French and Austro-Hungarian being already in hand.

The Collections of the Geological Society of London.—In accordance with the resolutions passed on June 14 that the collections of the Geological Society should be divided between the British Museum and Jermyn Street, it is interesting to note that the Foreign Series has already been removed to its new home at the British Museum (Nat. Hist.), is all in order in new cabinets, and can be referred to by responsible students.

Bristol Museum.—Mr. Herbert Bolton, F.G.S., curator of the Bristol Museum of Natural History, has been appointed reader in palæontology in the University of Bristol.

[1] Quart. Jour. Geol. Soc., vol. lxii, p. 528, 1906.

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Dr. GEORGE J. HINDE, F.R.S., F.G.S.
Sir THOMAS H. HOLLAND, K.C.I.E., A.R.C.S., D.Sc., F.R.S., F.G.S.
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SEPTEMBER, 1911.

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of the
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to illustrate the paper
by the Rev. R. A Bullen, B.A., F.G.S.
N.
Twelve fathom line
Ledge Flats
Flats
Shoals
North Rock
Ledge
1 to 6 ft. along these edges
Murray Anchorage
Flat
Narrows (Ship) Channel
Manhattan Shoal
St. David's Head
Phosphoritic Rock (coprolitic "guano" rock) from Manhattan Shoal
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Hungry Bay
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Astwood's Bay
Warwick Long Bay
Note
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Near Hungry Bay
At Kempe's Bay
Bailey Bay
Somerset
abundant P. bermudensis var. zonatus Verrill
St. George's N. shore &c.
Elbow Bay
Tuckerstown
Warwick Long Bay
Blown sands
S.W. of Castle Harbour
Paynters Hill (near Tuckerstown)
Joyce's Cave
Bailey Bay (below highwater mark)
Admiral's Bay near Spanish Point
Ireland Island N. Bastion &c.
fossil and extinct P. nelsoni
65°
32° 30
32° 20'
50'
40'
A. M. R. fecit.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VIII.

No. IX.—SEPTEMBER, 1911.

ORIGINAL ARTICLES.

I.—Some Notes on the Geology of the Bermuda Islands.

By R. Ashington Bullen, B.A. (Lond.), F.L.S., F.G.S.

(PLATES XVIII–XX.[1])

I. General Introduction.
A. E. Verrill. A. Agassiz. Nelson. Wyville Thomson.
Vulcanological Substratum. Rev. Osmond Fisher, F.G.S.
Evidence. (*a*) Charting. (*b*) Magnetic Deflection. (*c*) Analogy.

II. The Prevailing Winds. Evidence. Result.

III. The Principal Geological Formations.
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(3) 'Pseudo-palmetto Stumps,' Hungry Bay, Walsingham Formation.
(4) Soft Limestone Rock overlain and underlain by indurated, reticulated Limestone, west of Hungry Bay, Paget Formation.

I. General Introduction.

The geology of the Bermuda group of islands has been so exhaustively treated by Professor Verrill, Dr. Alexander Agassiz, and Lieutenant (afterwards General) Nelson (in what will always be the classic memoir on the subject) that it may seem presumptuous for another description to appear. However, as there are

[1] Plates XXI–III will appear in October with Part II of text.

some new facts to record, and nothing has yet appeared in the GEOLOGICAL MAGAZINE on the geology of Bermuda, a paper may be not altogether out of place.

In February last, when I told him of my intention to visit Bermuda, our veteran authority on the physics of the earth's crust, the Rev. Osmond Fisher, wrote: "The Bermudas are, I think, entirely volcanic. But I suppose quite anciently so, and that there are no cones, etc., now. There must be some interesting questions connected with them regarding changes of level of the ocean bed." Mr. Fisher was, of course, referring to the substratum of the islands. The evidence for the vulcanological origin of that proto-Bermudian land is threefold.

(*a*) *Charting.* There is the evidence of the Admiralty charts. In the narrative of the cruise of the *Challenger*[1] we find that the distance of 6 miles from the reef edge on the north-west of the group gave a sounding of 1,370 fathoms, and at 10 miles 2,100 fathoms. The slope off the North Rock is steeper than that off the north-east of Castle Harbour, e.g.:

Slope off North Rock 1,370 f. at 6 miles distance from reef edge.
  ,, Castle Harbour 1,250 f. at 8 miles from the 100 f. line.
  ,, south-west of Long Bar 1,250 f. at 5 miles from the 100 f. line.
  ,, north-east of East Ledge 1,000 f. only 2 miles from the 100 f. line, and 1,260 f. at 5½ miles from the 100 f. line.
  ,, south-west of the South-West Breaker 960 f. only 2 miles from the 100 f. line.
  ,, off the Argus Bank 1,370 f. at 10 miles from the 100 f. line.

This sudden deepening of the underlying mountain of which Bermuda is the summit, with two submerged peaks called the Challenger and Argus Banks respectively to the south-west of Somerset, is in accordance with the steep slope of a volcano with three peaks. The present degraded Bermuda volcano has a height of about 15,000 feet, equal to Mont Blanc.

(*b*) *Magnetic Deflection.* General Lefroy, Governor in the seventies, found that his own observations did not agree with the Admiralty charts. Observations made by the *Challenger* Expedition showed a variation of 6° in various parts of the islands, ranging from 4° W. to 10° W., the smallest amount being found at a small islet under Gibb's Hill and the greatest at the point west of Clarence Cove. The disturbing cause is probably the existence of iron rocks within varying depths from the present surface.

(*c*) *Analogy.* The well-known volcanic character of the Madeiras, Azores, Canaries, and other islands and rocks in the Atlantic would argue a similar origin for the Bermuda group. The islands mentioned are of Tertiary date,[2] but it is impossible to state the date of the Bermudas under present evidence. Verrill correlates them with Martinique and the West Indian group. Speaking of the main mass and also of the Challenger and Argus Banks he says, "No doubt each of these peaks and craters when they were most active rose high

[1] Wyville Thomson, *Voyage of the "Challenger"*, vol. i, p. 105. Also A. Agassiz, *A Visit to the Bermudas in 1894*, pl. ii (q.v.).
[2] *Student's Lyell*, ed. Judd, p. 501.

above the level of the sea, like the volcano of Teneriffe, though not so large or so high. Perhaps more like Martinique, Dominica, and St. Lucia among the Antilles. The size was similar to some of the latter, and there may have been many eruptions as violent as the recent eruptions from Mount Pélé and from as lofty a crater. In fact, there must have been a great many eruptions to have built up such an immense cone from the bottom of the deep ocean . . . during the Jurassic period reefs of corals existed as far north as Middle Europe, and the climate in the latitude of Bermuda in the Cretaceous and Eocene was no doubt much warmer than at present. In any case, the final result of the erosion of the larger volcanic cone must have been to form submerged banks or shoals at a suitable depth for the abundant growth of corals, mollusks, etc.

"George's Banks and Nantucket shoals off Cape Cod maintain themselves in the face of most violent storms; although composed of only sand and gravel, their shallowest parts rise to within 25 or 30 feet of the sea-level. This indicates that the erosive power of the sea waves decreases very rapidly, even at such depths." [1]

It is popularly supposed that Harrington Sound, Bermuda, is the crater of a volcano, but the charted soundings give no support to this idea. What there is deep down beneath we have no way of determining, but the depths are consonant with the features of a submerged valley, and that is all that can be said.

It is due to the prescience of Nelson that the true character of the present Bermudian rocks is known. At least, I give this statement on the authority of Wyville Thomson [2] and A. Agassiz.[3] I have not found the actual statement by Nelson himself.

Whether the primary rocks (moulded on the Bermudian volcano), now deeply submerged, are of the nature of coral-reef structure, cannot at present be ascertained. But all the rocks that can be examined are of 'æolian formation', a description attributed to Nelson by Wyville Thomson and A. Agassiz.

II. The Prevailing Winds.

The peculiar form of the Bermudas and the greater height of the land on the southern side have been caused by the prevailing winds. Although there are breezes and even at times hurricanes from the north and north-east, the prevailing winds are from the south-westerly direction. This is evident from the fact that the sand-dunes are forming on the south side of the main island, e.g. at Tuckerstown, Elbow Bay, Warwick Long Bay, etc. Nelson says, "Bermuda is not subject to any regular wind; perhaps to the south-west more than to any other." [4]

[1] A. E. Verrill, "The Bermuda Islands: Geology": Trans. Conn. Acad. Arts Sci., vol. xii, p. 55.

[2] *Voyage of the "Challenger"*, vol. i, p. 307.

[3] *A Visit to the Bermudas in 1894*, p. 221. "Captain Nelson was the first to call attention to the æolian character of the rocks of the Bahamas and Bermudas. This character *saute aux yeux* in every direction."

[4] "The Geology of the Bermudas": Trans. Geol. Soc., ser. II, vol. v, pt. i, p. 104.

Similar evidence of this fact is supplied by others. "The south-west wind, the prevailing one, is generally preferred by the natives, as the warmest in winter and the coolest in summer . . . in the winter months the weather is delightfully bracing, when the wind is northerly without being too boisterous." [1]

"The prevailing wind throughout the year is from the south-west. The northerly winds are comparatively dry, but those from the south are vapour-laden . . . 9 grains to the foot of air being the average maximum of dampness and 6½ the general average." [2]

The result is, and probably has been throughout the various stages of the existence of the Bermudas, that the highest land was always to be found along the south side of the islands and the lowest towards the north. A glance at the Map (Plate XVIII) will show the reason that the greater part of the old Bermudian land is below the waves. For a subsidence of a very small amount would suffice to bring the lands on the northern side within the disintegrating action of the ocean waves. The flats that form part of that submerged land are fairly level in their general surface and only a slight distance under water, sometimes only about a foot, as may be seen in the photograph of the Governor (General Lefroy) and others standing on the flats near the North Rock in 1875.[3]

Harrington Sound is almost landlocked, and the water in the deepest parts is from 10 to 12 fathoms. The main current runs out at Flatts Village, but a great deal more reaches the sea by underground passages, as may be seen at the west of Castle Harbour (Text-fig. 3), where a great body of salt water pours through the beach as the tide goes down. Harrington Sound was undoubtedly once a valley in Proto-Bermuda, and the present depth of its floor may be taken as a measure of the subsidence which the former land has undergone, with perhaps some other, slighter oscillations.

A Bermuda elevated this amount above the present mean level of the ocean would measure about 230 square miles, instead of 19⅓ as at present, which seems to be the closest measurement made. This land Verrill calls Pliocene Bermuda. It may contain rocks of an even earlier age at its base, but the higher points and ridges of land are still underlain by the hard base rock in which are to be found the caves for which the Walsingham district of Bermuda is famous. All the caves may not, however, be of this age. But it is difficult to see how this formation can be attributed to any more recent origin, since, for reasons which will be apparent later on, it precedes the red clay which must have been formed at a time of great rainfall, and may be placed in the Pleistocene period, or probably earlier.

III. The Principal Geological Formations.

The principal geological formations of Bermuda are four: (1) the Walsingham, (2) the Devonshire, (3) the Paget, and (4) the Recent. The names Walsingham, Devonshire, and Paget are taken from the names of the parishes in which the several formations can be best studied.

[1] A Field Officer, *Bermuda*, 1857, pp. 31–2.
[2] Nelmes' *Bermuda Guide*, p. 54.
[3] Verrill, op. cit., p. 117.

2


1


1. Sand-dune anchored by sea-lavender.
2. Sand-dune anchored by indigo-berry.
Both from Warwick Long Bay, south shore.

(1) *The Walsingham Formation.* This is Verrill's proposed name for the older rocks that are in sight, and he has so named them from the fact that in the north-east of the main island, round Harrington Sound and Castle Harbour, is the best place to study these hard and more or less crystalline æolian limestones. The beds are essentially

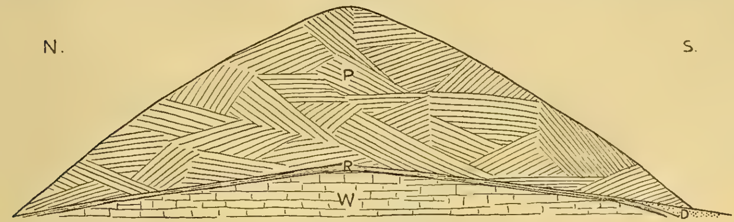


FIG. 1. Ideal section of Bermuda Formations. W, Walsingham formation (Pliocene); R, the red earth; D, Devonshire formation, Leda Clay (Glacial of Prestwich); P, the Paget, Post-Glacial and Recent formation.

of the same nature as the rest of the Bermudian limestones of later date, but by the infiltration of water supersaturated with calcic carbonate the æolian character is largely masked, the bedding-planes are nearly or altogether obliterated, and the hard limestone takes on a generally homogeneous appearance. But in this formation there are places where the shell sandstone of this age is friable and others where the shell-sand is found in pockets quite unconsolidated.

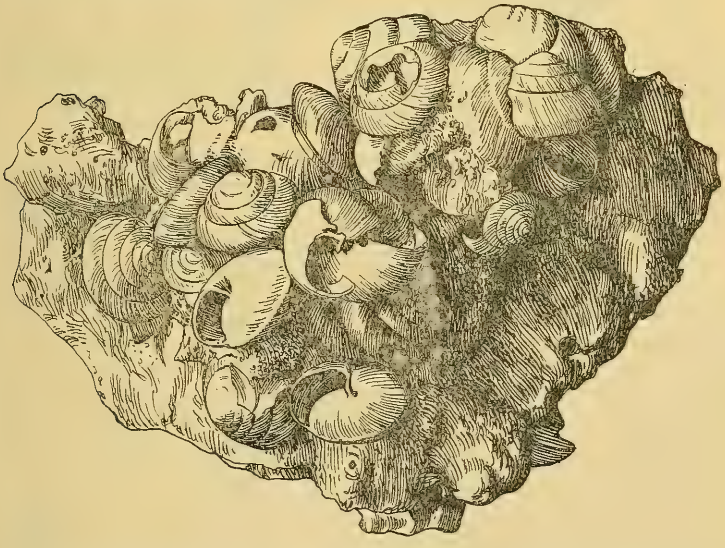


FIG. 2. Shell-conglomerate made up of a mass of shells of an extinct species of land-snail, *Pœcilozonites Nelsoni*, etc. Drawn by G. M. Woodward from the collection brought from Bermuda and presented to the British Museum (Nat. Hist.) by Major Peile.

Although the Walsingham Beds are best studied in the north-east district they are not confined to it. Admiral's Cave at Spanish Point is in this formation, for in it is to be found the extinct endemic species of land mollusc, *Pœcilozonites Nelsoni* (Bland), Pils., which may be taken as the characteristic fossil of these beds. Major Peile has added a fine series of this and other fossil and sub-fossil Zonitidæ to the British Museum, together with marine fossils from the higher Devonshire Series of Bermuda.

Much of the rock of this period, however, has no distinguishing fossil. The *P. Nelsoni* would only be found where the habitat had been congenial to it. There were spots where it flourished under favourable conditions of food-plant, shelter, and other advantages, just as to-day in places such as the blown sands of Cornwall, Norfolk,

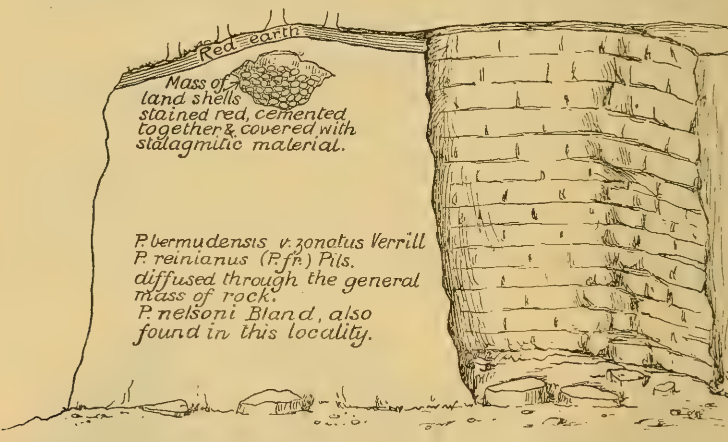


FIG. 3. Diagram sketch of cliff, west shore of Castle Harbour, to show deposit of land-shells. [No photograph was possible under the conditions of distance and sunlight available.] Surface covered with jungle of Bermuda juniper, sage, and ipecacuanha, festooned and overgrown with Cape jessamine. Sea-water discharges through the beach below from hidden caves draining Harrington Sound. The district is honeycombed with caves. On the right is a large quarry of hard crystalline limestone (Walsingham formation).

Brittany, Mallorca, and Spain land mollusca are abundant in some places, and for no readily ascertainable reason are absent under what appear to be identical conditions in others. The abundance of *P. Nelsoni* and its companion species, *Bermudensis*, *Reinianus*, *circumfirmatus*, which outlasted it, points to an abundant rainfall far greater than that which now obtains in these islands.

On the west shore of Castle Harbour, on Mr. Peniston's land, there occurs a cliff of hard Walsingham limestone, which contains scattered through its mass abundant specimens of various Helicidæ, and in a small cave or pocket, about 16 feet above the shore and quite unreachable without a ladder, a mass of the same shells is conglomerated together with a calcareous cement of stalagmitic character.

These shells are light in weight, bleached, brittle, and have lost their animal membrane seemingly, and are adherent slightly to the tongue. The caves owe their existence to the abundant rainfall during Pliocene and later times, and have been formed by solution and by underground streams very much as the caves of the Causse district in France and those of Derbyshire have been dissolved out. It will be seen in the later part of this paper that the sea can have had little or no part in their causation except where the caves are situated on the shore, and in this case they have apparently only been irrupted, not formed, by the sea. The sea, as at Cathedral Rocks in Somerset parish, has rather destroyed and opened out cavities which were previously existing.

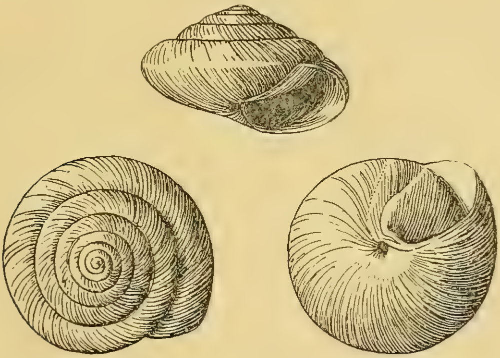


FIG. 4. *Pœcilozonites Bermudensis*, var. *zonatus*, Verrill, from Castle Harbour Cliff. (Specimens from the later Paget rock formation; in the brightness of their colour and state of preservation are comparable to the *H. nemoralis* of the Abbott Fissure at Ightham.) Drawn by G. M. Woodward.

It is said that for crystallization to take place there must not only be abundance of water supersaturated with calcic carbonate, but also rapid evaporation. This is probably true. But it is probably true also that, given efficient drainage, the matter in solution is deposited by the arrest of the running and percolating water, and that the calcic material may be precipitated quite as much by such arrest as by evaporation. It would be difficult otherwise to account for the thick deposits in the immense caves of Kentucky, Belgium, Mallorca, and elsewhere. For though evaporation can never be very great in the cool depths of such caves, the enormous deposition of stalactite and stalagmite is a fact everywhere patent in them.

At the top of the Walsingham formation there is a layer of red soil (see Text-fig. 1). This is due seemingly to the solution of the overlying shell-sand, just as the red clay (on the Chalk plateau) is partly due to the dissolution of the Chalk. In Bermuda the red clay must be wholly a dissolution product. The shell-sand which makes up the great mass of these æolian sands is not all soluble, and some of the material is left after the calcic material has been dissolved out. This residuum is taken to represent the remains of 150 feet of shell-sand for every foot of its depth. Taking the average depth as 8 inches, this would give a removal of 100 feet of denuded strata from above the Walsingham formation. However, this is not all the waste. This dissolving in all probability took place mostly in Pliocene and partly in early Pleistocene times. Some solution is, of course, also still going on slowly. But the total denudation of this period is probably for the average of 18 inches of soil (red) at least 225 feet. The proportions of the red soil vary greatly according to the source of the sample analysed. The shell-sand contains from ·005 of earthy impurities upwards (insignificant as this seems it amounts to 5 tons of every thousand dissolved), and the analyses show calcic carbonate, as well as oxide and sulphate, magnesic carbonate, alumina, ferric oxide, sand, insoluble clay, silica potash, soda, carbon dioxide, etc.[1]

Dr. A. Russel Wallace thought that the red earth was produced from pumice thrown up by the sea. But, as Agassiz says, "Although I examined the beaches of the south shore many times, I never succeeded in finding a single piece of pumice. Red earth is abundant, both in the Bahamas and Bermudas, in localities to which drift pumice could not have access."[2] These red layers, from 2 to 10 inches thick, interstratified with the limestone of the Walsingham period, are clearly seen in several sections. The 8 inch upper layer becomes a line of demarcation as good as we are likely to obtain. This red soil was proved at Prospect Hill, in a military boring at a depth of 130 feet and at 65 feet above O.D.[3] As the same red clay descends nearly to the shore at Hamilton, an ideal section of the underlying Walsingham rock would be of a saddle shape, taking the direction of north and south, and the Devonshire and Paget formations would lie against or above it respectively. The Walsingham formation probably underlies the whole length of the islands and reaches its greatest height somewhere about Prospect Hill or Sears Hill, though it is about 50 feet or so below O.D. at and near Ireland Island.

On Mr. Richard Kempe's land in Warwick parish the underlying rock is of a hard crystalline nature and the soil is red but not very deep, and on the northern slope, about the 50 feet contour, the limestone is of a crystalline nature, with veins of fine calcitic crystals resembling the calcite of the Oreston Cave, near Plymouth. Everywhere I examined the same fact holds good, the red soil is underlain by hard rock.

Verrill considers that most of the serpuline atolls and outlying flat reefs of the south coast are composed of the hard limestones of the Walsingham period, although the characteristic extinct fossil land-snails have as yet not been found in these reefs.[4]

(2) *The Devonshire Formation.* There has been much discussion about the position and date of the beach rock. Some of the older and more elevated of the beach rocks indicate that they were formed in

[1] Verrill, "The Bermuda Islands: Geology": Trans. Conn. Acad. Arts Sci., vol. xii, pp. 490, 493.

[2] A. Agassiz, op. cit., p. 236.

[3] The thickness was 8 inches according to Goldie, Lecture on the Geological Formation of Bermuda, 1893, pp. 14, 15.

[4] Op. cit., p. 73.

a period of depression. Some of these now lie 12 or 16 feet above the sea, and by the fine character of the materials and good condition of the shells appear to have been formed in quiet waters and not tossed up by hurricanes. These delicate shells and Foraminifera (such as are found at depths of from 3 to 5 fathoms) indicate that after deposition the beds containing them have been raised 20 to 30 feet or more above their previous level.[1]

As these deposits are well developed at Devonshire Bay, Verrill has proposed the name of Devonshire Beds for them. They contain some twenty species of Pelecypoda and thirty-one of Gasteropoda, all marine.[2] At Hungry Bay delicate shells of Mollusca—*Cæcum*, etc.—were found entire in the finer layers of rock.

Verrill gives the following species as not certainly known to be living in Bermudian waters at the present time: *Strombus accipitrinus*, Lam.; *Fasciolaria distans*, Lam.; *Scala* sp.; *Venus*, a large lamellose species; *Turbo* (*Livona*) *pica* (L.); *Callista* (? *maculata*); *Phacoides Pennsylvanicus*, var. *Somersensis*, Verrill; *Balanus*, a large massive species; ? *Mycetophyllia Lamarckiana*, Ed. & Haime; ? *Mæandra areolata* (L.), Oken; *Melitta testudinata* (Klein). All the beach rocks are not of this age—which Verrill places about the Champlain or Post-Glacial Period—but some are doubtless being formed still and also destroyed by storms that occasionally occur with great violence. (The Champlain or Leda Clay period belongs to the Glacial Period according to Prestwich.)

Agassiz, however, groups all these beach rocks as of recent origin and formed since the islands attained their present level. His own observation leads him to look upon the beach rock of the Bermudas as consisting mainly of the larger and heavier æolian materials, which either have not been carried so far or blown to so great a height as the lighter æolian sand.[3] He considers that all the beach rock has been formed from recent shell-sand by the hardening action of salt water and rain. In England such beach rock is forming on the seashore near the cliffs on the west of Harlyn Bay by the infiltration of rain-water through the blown shell-sand cliffs to the beach. A shelf some 40 yards long and 2 or 3 yards wide is thus in process of consolidating. Some of the Bermudian beach rock may have been formed in this way, but Verrill seems to have made out a very good case for the distinct character and intermediate date of some of these marine beach beds as being of a precedent origin to the formation we have next to consider.

These Devonshire Beds would lie unconformably against and not overlie the higher parts of the earlier Pliocene Walsingham Beds, if the fact is that these latter form a spine for the whole length of the islands, since we have seen that the latter beds are of a height of 65 feet above O.D. at Prospect Hill and no doubt elsewhere, whereas the submergence suggested by Verrill may be put at only 14 to 18 feet.

(3) *The Paget Formation.* The last series of rocks overlies the Devonshire Series, and is generally composed of consolidated soft

[1] Verrill, "The Bermuda Islands: Geology": Trans. Conn. Acad. Arts Sci., vol. xii, p. 189.

[2] Op. cit., pp. 76, 190.

[3] A. Agassiz, op. cit., p. 225.

shell sandstone of æolian origin. There are about 150 feet of this rock probably, and being the last of the Bermudian rocks it has not suffered so great an amount of denudation as that to which the Walsingham Series has been subjected. The Paget rock forms the principal source of the building and roofing-stone of the islands, and is cut in the quarries with a peculiarly-shaped saw into blocks of suitable size and thickness for building and roofing respectively. The rock is porous in texture and readily admits rain. It consequently has to be whitewashed, and then may be said to be sufficiently impervious to rain to form a suitable building material. Houses so built are not, however, altogether dry. It can easily be seen that the porosity of this rock allows the rain to sink away and prevents the formation of surface streams. Most of the wells are brackish, since the porosity of the rock allows the sea-water to percolate below O.D. Warwick Pond, e.g., seems to be in direct communication with the sea, although far inland.

It is in this series that the shells of *Turbo* (*Livona*) *pica* are found. They also occur in the Walsingham Series. These have been carried to various levels by the hermit-crab *Cenobita diogenes* (L.), whose fossil remains have been found in them. There is some doubt whether these fossil turbinoid shells[1] have not been collected from more modern sand-dunes, having fallen out of the more ancient rocks to the beach,[2] but this is unimportant since the cause of their being found at various levels has been sufficiently demonstrated. Abundant burrows of land crabs are to be seen on the south shore at Astwood's Bay, Kempe's Bay, and elsewhere.

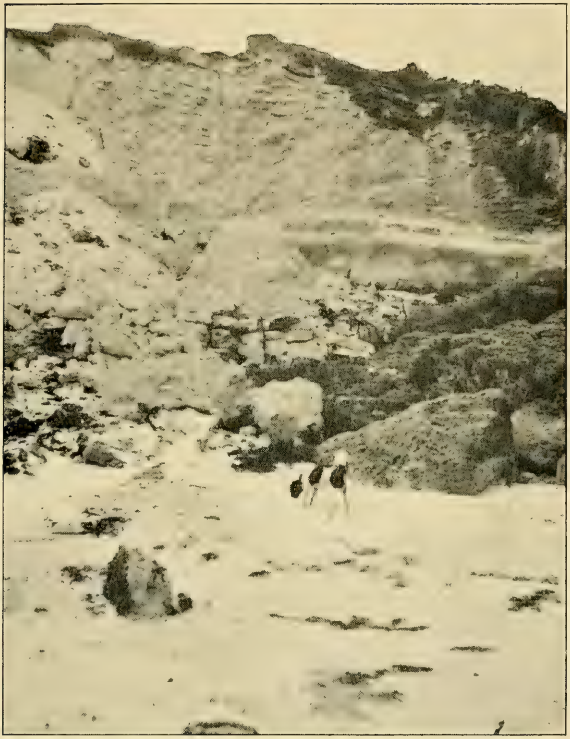
In the museum at Hamilton is to be seen the head and a part sawn off from the carapace of a leather-back turtle, *Sphargis coriacea* (L.), Gray; the locality is not stated, but from the condition of the remains (which were entire when found) it is most probably from the Paget formation. It would have been from 900 to 1,000 lb. in weight.

From the Paget Rock near Hamilton have also been obtained fossil eggs of some indeterminate sea birds (possibly some also of turtle's); one from Devonshire parish was found at a depth of 4 feet, another from Smith's parish at 15 feet, and one, in March, 1896, at 28 feet (loc. incert.) below the surface. They were sawn through in the operation of quarrying, but their outline is well preserved, and in one case the inside is filled with shell-sand, having evidently been broken by some accident at the time of laying or shortly afterwards. One turtle and at least one bird seem to have been overwhelmed by a sand-fall, but whether these belong to this or the Walsingham Series, or to what species they are to be credited, there is no evidence to show.[3]

[1] Nelson, "The Geology of the Bermudas": Trans. Geol. Soc., ser. II, vol. v, pt. i, p. 112, says, "It seemed difficult at first to account for these large shells (*Turbo pica*) being found on heights where from their weight it was impossible to suppose they had been carried by the wind; but a solution may be found in the habits of the soldier-crab, which on more than one occasion I have seen running about in these shells." See Verrill, "Geology of Bermuda," p. 197, with picture from life of a land hermit-crab in a fossil shell of *Livona pica*.

[2] I have one specimen of *Livona pica*, found on the present beach, which has evidently weathered out of the Paget Rock and fallen to the beach.

[3] Verrill, op. cit., p. 195.

1 

2 

1. Recent landslip (Paget formation), Kempe's Bay, Bermuda.
2. Serpuline atolls, south shore, Bermuda.

There are also fossil remains of the shearwater (*Puffinus obscurus*, Hurdis & Reid; *Auduboni*, Finsch) from Smith's parish. Mr. L. L. Mowbray, the curator, has mounted the sternum found alongside of the recent skeleton of the shearwater, with whose measurements the fossil agrees.

EXPLANATION OF PLATES.

PLATE XVIII.

Map of Bermuda, showing principal points touched on in the paper. Drawn by Mrs. Bullen.

PLATE XIX.

Fig. 1. Sand-dune 'anchored' by sea-lavender (*Tournefortia gnaphaloides*, R. B.).
,, 2. Sand-dune 'anchored' by indigo-berry (*Randia aculeata*, L.).
Both Figs. 1 and 2 from Warwick Long Bay, south shore.

PLATE XX.

,, 1. Recent landslip, Paget formation, Kempe's Bay, Warwick parish, south shore.
,, 2. Serpuline 'atolls', south shore.

(*To be concluded in the October Number.*)

II.—A Carboniferous Arachnid from Lancashire.

By E. Leonard Gill, M.Sc., Curator of the Hancock Museum, Newcastle-upon-Tyne.

THE specimen represented in the accompanying figure was obtained from the Coal-measures of Westhoughton, near Bolton, Lancashire, and has been kindly lent to me by Mr. Thos. Midgley, of the Chadwick Museum, Bolton. It is the nearly complete abdomen (opisthosoma) of an arachnid of the order Anthracomarti. The concavity of the outer margins of the pleural laminæ, producing the scalloped outline shown in the figure, indicates at once that the specimen must be assigned to the family Brachypygidæ[1]; but it is less obvious to what genus it may belong. Mr. Pocock's monograph (see preceding footnote) gives only two genera as known in the family, namely *Brachypyge*, Woodward, and *Maiocercus*, Pocock. Comparison between these two is rendered difficult by the fact that of the former only the dorsal surface is known, of the latter only the ventral; of neither has any part but the opisthosoma yet been recognized. Accordingly, in differentiating his genus *Maiocercus* from *Brachypyge*, Mr. Pocock[2] was compelled to fall back upon two characters—the general shape of the opisthosoma and the angles made by the anterior pleural laminæ. *Brachypyge* is defined as having the "opisthosoma much longer than wide; pleural laminæ of the second and third pleura-bearing terga inclined slightly backwards"; *Maiocercus* as having the "opisthosoma much wider than long; pleural laminæ of the first, second, third, and fourth sterna inclined slightly forwards".

These definitions fail when applied to the present specimen, for though on the whole the inclinations of the pleural laminæ agree with

[1] See R. I. Pocock, "Terrestrial Carboniferous Arachnida of Great Britain": Palæontographical Society, vol. lxiv, p. 58, 1911.
[2] Loc. cit., p. 59.

those attributed to *Maiocercus*, the other criterion, the proportion of length to breadth, does not help us, since the length and breadth are as nearly as possible equal. Nevertheless I am disposed on general grounds to refer this specimen, with very little hesitation, to *Maiocercus*. If I am justified in doing so, the specimen not only necessitates a slight modification in the definition of the genus, but adds largely to our knowledge of it. It is the dorsal surface that is shown, and up to the present only the ventral surface of *Maiocercus* has been described.

Since the dorsal surface of the opisthosoma of *Brachypyge* is well known (from Dr. Woodward's figure, copied in Mr. Pocock's monograph), direct comparison is possible between it and the present specimen. Considerable differences are obvious. The most important are those relating to the axial parts of the tergal plates, which are proportionately much wider than in *Brachypyge*; whilst the eighth tergum is not fused, as in *Brachypyge*, with the inner parts of its

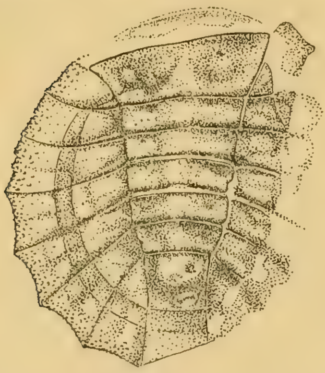


FIG. 1. *Maiocercus orbicularis*, sp. nov. Coal-measures, Westhoughton, near Bolton (dorsal surface of opisthosoma).

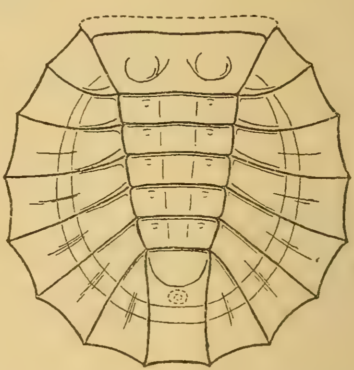


FIG. 2. *Maiocercus orbicularis*, sp. nov. (restored outline of opisthosoma).—Both figures drawn three times nat. size.

pleural laminæ. The various systems of sutures separating and subdividing the laminæ correspond in a general way in the two forms, but in *Brachypyge* they are apparently much more strongly marked than in this specimen from Westhoughton. A similar direct comparison with *Maiocercus*, of which only the ventral aspect is known, is naturally out of the question, and all that can be said is that the Westhoughton specimen presents us with a dorsal surface which is much what we should expect to find on the back of a *Maiocercus*. Incidentally it seems to confirm Mr. Pocock's surmise [1] that *Maiocercus* is in some respects more nearly related to *Anthracomartus* than to *Brachypyge*.

A few points of detail call for mention. The first somite is missing; the dotted outline in Fig. 2 is intended to indicate its absence rather than its probable form. The ill-defined plate lying in front of the

[1] "Terrestrial Carboniferous Arachnida of Great Britain": Palæontographical Society, vol. lxiv, p. 60.

second somite may possibly be a portion of the first, or the first in some displaced position; it is seen much better on the piece of shale bearing the impression than on the one bearing the fossil itself. Some hint as to the shape of the first tergum is perhaps given by the pleural laminæ of the second; these extend forward beyond the second tergum and their inner edges continue to diverge, as though to accommodate a first tergum which carried still further the spreading form of the second.

The succeeding somites, the second to the eighth, are well defined. The second is much larger than the rest; the third to the seventh are nearly equal in length and show a regular decrease in breadth; the eighth is narrower and longer than any of the others. The second tergum bears a pair of large but indistinct tubercles, and there are traces of smaller and still less defined tubercles occurring in pairs, one on each side, on the succeeding somites. A low, rounded ridge runs down the centre of the terga, originating in the triangular space between the tubercles on the second tergum. A rounded swelling occupies the anterior part of the eighth somite, and may have been present in life; it fits in well with the converging lines formed by the lateral edges of the preceding terga. Behind this swelling, and a little to one side, there is an oval papilla, grooved in the middle, which is possibly the imprint of a crushed anal plate lying below. The integument is preserved over the greater part of the fossil, and is everywhere finely granulated. It is missing, however, from the outer parts of the pleural laminæ (with the exception of the foremost lamina on the right), and these show towards their outer edge a rather coarser granulation and pitting. The original drawing of *Maiocercus celticus* [1] indicates a similar pitting on the underside of the laminæ. The concavity of the outer margins of the laminæ is not uniform. It is well marked in those of the fifth, sixth, seventh, and eighth somites, but not in those of the second, third, and fourth. In the case of these three anterior laminæ, however, I am inclined to attribute the shape of the margin to distortion. The whole front of the opisthosoma is bent somewhat backwards on the left side, and the edges of the anterior laminæ on that side are notched here and there in a way that suggests crumpling. In the restored outline I have assumed that these laminæ, if straightened out, would show nearly as much concavity of margin as those that succeed them.

The length of the opisthosoma is about 15 mm. and its breadth about the same. The opisthosoma of *Maiocercus celticus* appears to be of much the same breadth as that of the Westhoughton specimen,[2] but its length is only about 11·5 mm. This difference in general proportions presumably indicates specific distinctness; it is greater than can be accounted for with any probability by variability or by conditions of fossilization. Specific names have little value in such a case, but it might cause more trouble to leave the fossil unnamed than to add one

[1] By F. T. Howard & T. H. Thomas, Trans. Cardiff Nat. Soc., vol. xxviii, plate facing p. 53, 1896.

[2] I have estimated the dimensions of *Maiocercus celticus* from Messrs. Howard and Thomas's figure (see last footnote), which they state to be six times the natural size. The figure on p. 60 of Mr. Pocock's monograph must have been described as of natural size by mistake.

more name to the nomenclature of the group. I would propose, therefore, that it should be known for the present as *Maiocercus orbicularis*.

If the specimen is rightly ascribed to *Maiocercus*, the definition of the genus must be modified so as to cover an "opisthosoma wider than long or about as wide". The other point of Mr. Pocock's diagnosis, the forward inclination of the pleural laminæ, is not affected. Further diagnostic points, which may now be added regarding the dorsal surface, have already been indicated. It may be remarked that though the Westhoughton specimen approaches *Anthracomartus* in the general form and proportions of its tergal plates, it suggests affinities with *Brachypyge* in one or two respects apart from the concave borders of the laminæ. As already pointed out, there is some hint of a first tergum still wider than the second, as it is in *Brachypyge* but not in *Anthracomartus*. A less speculative point of resemblance to *Brachypyge* (and again of divergence from *Anthracomartus*) is the double line of suture crossing the pleural laminæ. On the whole, then, the new specimen, while it necessitates a slight change in the definition of the genus, not only further demonstrates the distinctness of *Maiocercus*, but tends also to strengthen its claim to stand with *Brachypyge* in a family apart from the other Anthracomarti.

III.—On a new species of *Desmoceras* from the Chalk Rock of Buckinghamshire.[1]

By A. H. Noble, B.A., F.G.S.

WHILST engaged on the new Geological Survey in the neighbourhood of Marlow, I had the good fortune to come across an exposure of Chalk Rock yielding an exceptionally rich fauna, including a single specimen of an ammonite which appeared to be new to science. This ammonite was therefore shown to Dr. Kitchin, Mr. Crick, Dr. Rowe, and Mr. H. Woods, none of whom had seen the species before or could recognize it as a form already described. The discovery of new Cephalopods from the Chalk is now so rare that it seems worth while to draw attention to this, although the whole of the accompanying fossils have not yet been identified.

The specimen is preserved in the form of an internal cast in very hard glauconitic chalk. It shows well the sutures, but is entirely septate, no part of the body-chamber being present. When complete it must have measured at least 55 mm. in greatest diameter and possibly more. In the earlier formed part of the outermost whorl the siphuncle is exposed to view as a narrow tube of dark-brown colour with glossy surface; in the later portions of the whorl the form of the tube is not preserved, but its course is well shown.

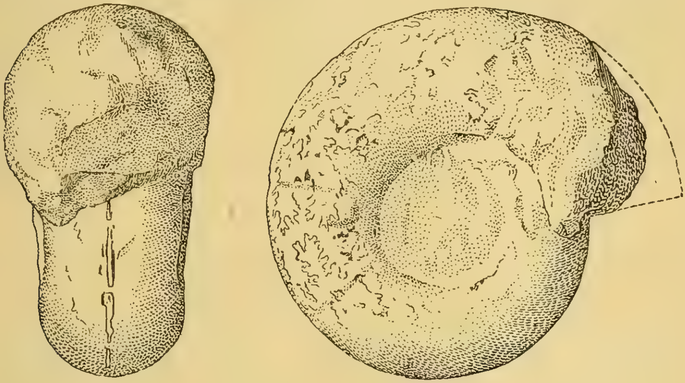
Desmoceras marlowense, sp. nov. (Figs. 1 and 2.)

The shell is discoidal, with the whorls increasing slowly, the height of the outer whorl being about two-fifths of the diameter of the shell. The inclusion is about one-half. The umbilicus is moderately wide

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

and shallow, its diameter (measured from the spiral suture) being rather more than one-third of the diameter of the shell. The peripheral area is broadly convex, sloping more steeply down to the point of maximum breadth of the whorl in cross-section, which is situated at about two-fifths of the radial diameter measured from the umbilical margin. The umbilical zone is fairly large, sloping steeply down to the spiral suture.

There is a series of constrictions, numbering about eight on a whorl. The course of these is straight up to the siphuncle, where the ligation becomes directed very slightly forward. No ribbing is visible on the cast, but there are some traces of nodular swellings, each one situated posteriorly to a constriction at the outer limit of the umbilical slope.



a *b*

FIG. 1. *Desmoceras marlowense*, sp. nov. *a*, front view; *b*, lateral aspect. Chalk Rock: Marlow, Buckinghamshire. Both nat. size.

The suture-line is well seen on several parts of the specimen, and can be traced from the siphonal line as far as the second lateral lobe. The external saddle is divided into two parts by a fairly deep lobe, that part nearer the siphuncle being slightly greater than the other part.

The first lateral saddle is about as high as the external saddle, but is simpler. The first lateral lobe is trifid and of the same length as the ventral or siphonal lobe. The second lateral lobe is similar to the first, but shorter and simpler.

Dimensions.	mm.
Greatest diameter	51
Height of outer whorl	21
Thickness of outer whorl in cross-section .	25
Width of umbilicus	19

Locality and Horizon.—The specimen was found in a small pit about one-quarter of a mile E.N.E. from Blount's Farm, Great Marlow. Here the whole of the Chalk Rock is exposed, and a very rich fauna was obtained from a band which occurs just above the green nodular band about 2 feet from the top of the Chalk Rock zone of *Holaster planus*.

The specimen is preserved in the Museum of Practical Geology, registered 25456.

Remarks.—It must be mentioned that the appearance of rapid modification to a less involute state, presented by the last-formed part of the last whorl as seen in Fig. 1*b*, is entirely due to the imperfect preservation of that part of the specimen. There also the peripheral region of the cast has become broken away, and is restored in the Figure by a dotted outline. It is not possible to say how much of the septate part of the specimen is missing, and the length that might have been attained by the body-chamber is, of course, also unknown. Although uncoiled or partially uncoiled ammonitoids, such as *Heteroceras*, *Scaphites*, *Crioceras*, and *Baculites*, are fairly common in the Chalk Rock, few species which are unmodified in this manner have been recorded. Mr. H. Woods has described two, *Pachydiscus peramplus* and *Prionocyclus neptuni*,[1] and Messrs. Chatwin & Withers have recently identified a new species, *Puzosia curvatisulcata*, from the Waterworks Quarry, Marlow.[2]

FIG. 2. *Desmoceras marlowense*, sp. nov. Part of suture-line. ×2.

The specimen here described is referred to the genus *Desmoceras* principally on the evidence of the suture-line, which is well shown. The lobes are trifid, the first lateral being of about the same length as the ventral. The saddles are similar to one another, and each one is divided into two parts. A certain degree of similarity is shown to *Desmoceras pyrenaïcum*, de Grossouvre, from the Middle Senonian (Santonian) of Sougraignes, Aude.[3] The suture-line is almost identical in the two forms, and they are alike in the presence of constrictions. These, however, are more oblique in their course and take a stronger forward bend on the peripheral area in the French species.

D. pyrenaïcum is considerably more involute, and the outline of the whorl also differs; the peripheral zone is more convex and the umbilical zone less steep than in the English form.

My best thanks are due to Dr. Kitchin and Mr. Clement Reid for their kind assistance in the preparation of this paper.

[1] H. Woods, "The Mollusca of the Chalk Rock," Part I: Q.J.G.S., vol. lii, pp. 77, 79, 1896.

[2] C. P. Chatwin & T. H. Withers, "Contribution to the Fauna of the Chalk Rock": GEOL. MAG., Dec. V, Vol. VI, p. 66, 1909.

[3] A. de Grossouvre, "Recherches sur la Craie Supérieure," 2^e^ Partie: Mém. Carte Géol. France, p. 168, pl. xxv, fig. 2, and pl. xxxvii, fig. 9, 1893.

IV.—On some Freshwater Mollusca from the Pliocene Deposits of East Anglia.

By A. S. Kennard, F.G.S., and B. B. Woodward, F.L.S., etc.

NON-MARINE Mollusca are extremely rare in the Pliocene deposits of this country, which fact must always be a matter of regret to the Palæontologist, since they are of the utmost importance in connexion with the origin of our present fauna. Unfortunately, in addition to their rarity, they are often decorticated or fragmentary, whence no doubt the differences in opinion as to their correct determination. A re-examination of all the available material has convinced us that there is still much to be done before it will be possible to reach finality. In these matters so much depends on one's standpoint. If one starts with the preconceived idea that the Pliocene shells must be identical with the recent forms, it is easy enough to identify them, even if one has to go to Japan or Greenland to find its present habitat. If, on the other hand, one considers it better to study carefully the results of recent work on other branches of the fauna, it is obvious that different results will be arrived at. Hence we are quite prepared for any differences of opinion as to the correctness of our views or the wisdom of creating four new species, as we now venture to do.

1. Limnæa Harmeri, n.sp.

Shell elongate, oblong-conic, thin; spire elevated, slightly turreted; apex acute; whorls 6 (or $6\frac{1}{2}$?), convex, smooth; suture fairly deep, oval, entire; inner lip reflected, but seemingly not spread on the columella and does not conceal the umbilical chink. Height 15, breadth 7 mm.; aperture, length 6, breadth 4 mm. Pliocene—Norwich Crag (Icenian): Bramerton, Norwich. Type in the Norwich Museum.

Limnæa Harmeri, n.sp. (The scale represents millimetres.)

This species is only represented by a single example, but there can be no doubt as to its specific distinctness. It may be distinguished from *L. tenuis*, S. Woodward (*Geology of Norfolk*, tab. 3, fig. 30) (= *L. palustris*, Müll., of S. V. Wood, *L. palustris*, Müll., of Kennard and Woodward, *L. elodes*, Say, of S. V. Wood, and *L. pingelii*, Möll., of S. V. Wood), by its more pronounced suture, more convex whorls, and markedly oval mouth. Though bearing a superficial resemblance to some forms of *L. palustris*, Müll., in all probability it has no affinity with it.

We have great pleasure in associating with this species the name of Mr. F. W. Harmer, in recognition of his lifelong work among the later deposits of East Anglia.

2. Limnæa Butleyensis, n.sp.

Shell small, ovate-conic, thin; spire elevated, somewhat turreted; apex acute; whorls $5\frac{1}{2}$, convex; suture deep; aperture ovate, slightly contracted on the inner side; umbilicus nearly closed. Pliocene—Red Crag (Butleyian): Butley, Hollesley, Suffolk. Norwich Crag (Icenian): Bramerton, Thorpe, Norfolk. Type in our collection.

This is the *L. truncatula*, Müll. (?), of S. V. Wood (*Crag Moll.*, vol. i, p. 8, tab. 1, fig. 8*a*), the *L. Holbollii*, Möll., of S. V. Wood (op. cit., supp., p. 3), and the *L. truncatula*, Müll. (*pars*), of Kennard & Woodward (Proc. Malac. Soc., vol. iii, p. 197).

This species may be distinguished from the polymorphic *L. truncatula* in being larger, in having the mouth more oval, whilst the whorls increase much more regularly. It is doubtful if *L. Butleyensis* has any real affinity with *L. truncatula*, nor can it be looked upon as a possible ancestor of that species. The largest example we have seen measures 12 mm. in height and 6 mm. in breadth.

The measurements of the type-specimen are: height 10, breadth 5 mm.; length of aperture 5, breadth 3·5 mm.

3. Limnæa Woodi, n.sp.

Shell small, ovate-conic, thin; spire elevated, little more than half the total length, turreted; apex rather acute; whorls $4\frac{1}{2}$, somewhat swollen; suture deep; aperture ovate, slightly contracted on the inner side; umbilicus nearly closed; body-whorl striated parallel with the aperture. Height 6, breadth 4 mm.; aperture, length 3·7, breadth 2·5 mm. Pliocene—Red Crag (Butleyian): Butley, Suffolk. Norwich Crag (Icenian): Bramerton, Norfolk.

This is the *L. truncatula* (?), Müll., var. B, of S. V. Wood (*Crag Moll.*, vol. i, p. 8, tab. 1, fig. 8*b*). It may be distinguished from *L. Butleyensis* by its much smaller size, shorter spire, and relatively larger body-whorl. It is apparently a rare form, for we have only seen one example; this, which is in our collection, and is from Butley, we take as the type. There can, however, be no doubt that the example figured by S. V. Wood from Bramerton, which we have been unable to trace, is identical.

4. Planorbis præcursor, n.sp.

Shell sinistral, discoidal, smooth; spire depressed, nearly flat beneath; margin slightly carinated; aperture simple, lunate, subquadrate, oblique; outer lip thin, inner lip slightly spreading over the body-whorl. Pliocene—Red Crag (Butleyian): Butley, Hollesley. Norwich Crag (Icenian): Bramerton, Southwold, Bulcamp, Coltishall.

This is the *P. complanatus*, Linn., of S. V. Wood (*Crag Moll.*, vol. i, p. 9, tab. 1, figs. 10*a–c*) and the *P. marginatus*, Drap., of Kennard & Woodward (op. cit., p. 197). It bears a superficial resemblance to the recent shell which is now generally known as *P. umbilicatus*, Müll., but it may be easily distinguished from that species. It is much smaller, the rate of increase of the whorls is much less, the carination is not so prominent, and it is a perfectly smooth shell, lacking the characteristic striæ of *P. umbilicatus*. The example in our collection, which we take as the type, measures 12×2 mm. It is not improbable that this Crag shell is the ancestor of the recent form, but better examples of *P. umbilicatus* (Müll.) from the Forest Bed (Cromerian) are needed before one can state definitely whether this view be correct.

V.—Palæontological Notes from the Manchester Museum.

Archæocidaris in the Middle Coal-measures of Lancashire; with Notes on other Species.

By J. Wilfrid Jackson, F.G.S., Assistant Keeper, Manchester Museum.

In the course of working through the large collection of Coal-measure fossils in the Manchester Museum I have recently discovered a number of interesting, and hitherto unrecorded, forms from the well-known 'Marine Band' in the Middle Coal-measures of Ashton-under-Lyne. The most interesting of these additions is undoubtedly *Archæocidaris*, a genus which is not at all common in the Coal-measures of this country, though fairly abundant in North America. Hitherto it has only been recorded from the North and South Staffordshire Coal-fields; its discovery, therefore, at Ashton constitutes the third record for the British Isles.

With the possible exception of the two forms of *Orthoceras*, which require further study, all the species mentioned below have been recorded from the Marine Band below the Gin Mine Coal, North Staffordshire Coal-field, and their occurrence in the Marine Band at Ashton, Lancashire, affords further confirmatory evidence of the correlation of these two bands.

Other species already recorded from the Marine Band at Ashton and Dukinfield are *Ctenodonta lævirostris*, *Pseudamusium fibrillosum*, *Pterinopecten papyraceus*, and *Listracanthus*, specimens of which are in the Manchester Museum.

Echinodermata.

Archæocidaris sp. This is represented by a fragment of the basal portion of a spine, its length being about 10 mm. Immediately above it is the cast of some 15 mm. more of the same spine, and just below is the impression of the basal end. The spine is very like that figured from below the Gin Mine Coal, North Staffordshire Coal-field,[1] and possesses similarly disposed spinules. The specimen forms part of the 'Wild Collection', and was obtained from the Marine Band (450 feet above the Great Mine Coal) at Ashton Moss Colliery.

Brachiopoda.

Orbiculoidea nitida (Phill.). After careful study I am unable to separate *Discina orbicularis*, Bolton,[2] recorded from the Ashton Moss Marine Band (Cairns Collection) and roof of the Bullion Coal, Carre Heys, Colne (Wild Collection), from dwarfed or immature examples

[1] Q.J.G.S., vol. lxi, p. 529, pl. xxxv, figs. 1, 1*a*, 1905.
[2] Manch. Memoirs, vol. xli, No. 6, pp. 2, 3, pl. v, figs. 1, 2, 1897.

of Phillips' species. It is true they are flatter than most examples, but this may be due to pressure. Specimens of *O. nitida* from Eccup, near Leeds (shale below third grit), agree with this form exactly. I have been unable to compare them with actual specimens from the North Staffordshire Coal-field, but from the illustrations in Dr. Hind's paper [1] the forms appear to be identical.

Lingula mytiloides, Sow. Several specimens of a *Lingula* (now in the Manchester Museum) were collected many years ago by Mr. R. Cairns at Ashton Moss Colliery. These were referred to by Mr. H. Bolton as *Lingula* sp. in his paper on the "Palæontology of the Lancashire Coal-measures".[2] A careful comparison with specimens of *L. mytiloides* from the Staffordshire Coal-field (over Moss Coal) and other places proves them to be that species.

Gasteropoda.

Loxonema acutum, de Kon. (?). In the Grundy Collection, recently acquired by this Museum, is the cast of a univalve, which, in all probability, is referable to this or some other species of *Loxonema*. It is 8 mm. in length and appears to consist of eight or nine apical whorls. Unfortunately no details can be made out owing to its bad state of preservation. The locality whence the specimen was obtained is the well-known Marine Band exposed on the bank of the River Tame at Dukinfield, its horizon being the same as that of *Archæocidaris*, etc.

Lamellibranchiata.

Posidoniella sulcata, Hind. Several specimens in the Wild Collection from Ashton Moss Colliery are referable to this species, Dr. Hind having kindly confirmed the identification of examples submitted to him. All the specimens are unfortunately very imperfect, but the ornament, consisting of concentric angular ridges, separated by fairly broad, concave sulci, agrees exactly with that of *P. sulcata*.

Dr. Hind states in his paper on the "Palæontology of the Marine Bands in the Coal-measures" (North Staffordshire)[3] that he is of opinion that he saw, several years ago, a specimen of *P. sulcata* from the Lancashire Coal-measures in the cabinet of the late Mr. Neild, of Oldham, but all attempts to trace the specimen have failed. He further adds, "Mr. H. Bolton[4] quotes *Posidonomya lateralis*, a synonym of *P. becheri*, as occurring in the Lower Coal-measures of Lancashire. Possibly he may have mistaken a specimen of my species for it." The specimen quoted by Mr. Bolton is in the Kay-Shuttleworth Collection in the Manchester Museum, and is labelled as coming from "Coal-measures, Burnley, Lancashire". I doubt very much that it comes from the Coal-measures at all, as the matrix is more like one of the impure Pendleside Limestones. The species is *P. becheri* undoubtedly, and associated with it is an obscure Goniatite.

[1] Q.J.G.S., vol. lxi, pl. xxxv, fig. 3, 1905.
[2] Trans. Manch. Geol. Soc., vol. xxviii, p. 584, 1904.
[3] Q.J.G.S., vol. lxi, p. 535, 1905.
[4] Trans. and Ann. Rep. Manch. Micro. Soc., 1895.

CEPHALOPODA.

Glyphioceras phillipsi, Foord & Crick (?). I have in my possession a small fragment of a *Glyphioceras* from the Marine Band, River Tame, Dukinfield, which suggests reference to this species on account of its ornament. The fragment appears to be pretty close to the aperture, and the test is ornamented with fine striæ, slightly waved on the side, curved forward near the periphery and on the latter forming a deep broad sinus.

Gastrioceras carbonarium (Von Buch). A fragment of a whorl exhibiting the tuberculated umbilical margin is referred to this abundant Lower Coal-measures form. It was obtained by me from the same band as the above-mentioned *Glyphioceras*.

Dimorphoceras gilbertsoni (Phill.) (?). This species appears to be represented in the Ashton Moss Marine Band by several immature examples in a small fragment of rock collected by Mr. R. Cairns.

Pleuronautilus costatus, Hind.[1] Two imperfect Nautiloids from the Marine Band, Ashton Moss Colliery, collected by George Wild, are considered by Dr. Hind to be identical with his species from below the Gin Mine Coal, North Staffordshire Coal-field. One much-crushed specimen is very like his fig. 5*a* of pl. xxxvi[2]; the other is an uncrushed fragment of the body-whorl displaying very clearly the ornamentation of the shell. It would be interesting to know the relation of this species to *Pleuronautilus rotifer* (Salter), recorded from the same Marine Band.[3]

Orthoceras spp. At least two forms of *Orthoceras* occur in the Marine Band at Ashton Moss and Dukinfield, both of which are represented in the Wild, Grundy, and Cairns Collections in the Manchester Museum.

The commonest form would clearly come under Professor de Koninck's[4] division "Orthocerata, 1st Lævia, A. gracilia", as the shell appears to possess a cylindrical siphuncle and a smooth or nearly smooth test. The species somewhat resembles in general form and slenderness the inferior ends of his *Orthoceras calamus* (pl. xxxviii, fig. 6) [= *O. inæquiseptum*, Phill.] and *O. martinianum* (pl. xliv, fig. 4).

A similar form, referred by Dr. Hind to *Orthoceras* aff. *asciculare*, Brown,[5] is met with in the Marine Band below the Gin Mine Coal, North Staffordshire Coal-field. The identification, however, of the Lancashire and Staffordshire specimens with Brown's species is, in my opinion, very unsafe. The original of his species came from the Pendleside Series, near Todmorden, and formed part of the Gibson Collection. The type-specimen (in the Manchester Museum) has, unfortunately, suffered considerable loss since Brown's time, as it now consists solely of the impression of the original organism on a fragment of black shale. The form, as will be seen by his figure,[6]

[1] Q.J.G.S., vol. lxi, p. 540, pl. xxxvi, figs. 5–5*b*, 1905.
[2] Op. cit.
[3] *Geology of the Country around Oldham* (Mem. Geol. Surv.), 1864, p. 64, pl. i, fig. 6.
[4] *Faune du Calc. Carb. de la Belgique*, 1880, p. 50.
[5] Q.J.G.S., vol. lxi, p. 542, pl. xxxvi, figs. 6, 7, 1905.
[6] Trans. Manch. Geol. Soc., vol. i, pl. vii, fig. 39, 1841.

is a much more slender one than the examples from the Lancashire and Staffordshire Coal-fields.

The second form of *Orthoceras* belongs to Professor de Koninck's division "Orthocerata, 2nd Annulata", as the surface is ornamented with numerous fine concentric rings. It is a much more robust species than the other, recalling *Orthoceras cinctum*, Sow., but the material available is too imperfect for accurate determination.

VI.—Notes on Two Arthropods from the Lancashire Coal-measures.

By J. Wilfrid Jackson, F.G.S.

SOME time ago the Manchester Museum purchased a selection of Coal-measure Fishes from the executors of the late Mr. John Ward, of Longton, and included with these were gutta-percha casts of two species of Arthropods. These were mounted on wooden tablets covered with green paper, one specimen being labelled: "*Limulus trilobitoides*, Buck. (*Bridgewater Treatise*, vol. ii, pl. xlvi, fig. 3). Roof of the Upper Bent Mine, Middle Coal-measures, Hunt Lane, near Oldham. Original in the cabinet of E. W. Binny, Esq." The other: "*Limulus rotundatus*, Prest. Coal-measures, Oldham."

The first-mentioned species (now recognized as *Belinurus lunatus*, Martin, sp.) is recorded by Salter in the Geological Survey memoir, *The Geology of the Country around Oldham* (1864), p. 63, as follows: "*Limulus trilobitoides*, Oldham (Manchester Geological Museum)." Bolton in his "Palæontology of the Lancashire Coal-measures"[1] also repeats this record, and adds: "The original specimen was deposited in the Natural History Museum, Manchester, but has disappeared."

No horizon is given by Salter for this species, nor does it appear to have been recorded since from any Oldham horizon; the fact, therefore, of the cast possessing full details as to precise locality and horizon is of particular interest.

It is much to be regretted that the second species (now recognized as *Prestwichia rotundata*, H. Woodw.) does not possess a like amount of information as to its horizon, etc. It does not, however, seem improbable that it is referable to the same horizon as *Belinurus lunatus*.

VII.—On the Layers of the Molluscan Shell.

By A. R. Horwood (Leicester Museum).

I AM glad that my short article[2] dealing with the occurrence of aragonite in the Middle Lias has evoked some interest. Professor Grenville Cole,[3] who notices (with Mr. O. H. Little) this paper, has evidently delved deep, and I only hope that the publication of

[1] Trans. Manch. Geol. Soc., vol. xxviii, p. 601, 1905.

[2] "On the Occurrence of Aragonite in the Middle Lias of Leicestershire; with some remarks on the calcareous character of the *spinatus* beds": Geol. Mag., 1910, p. 173.

[3] "The Mineral Condition of the Calcium Carbonate in Fossil Shells": ibid., 1911, p. 49.

my preliminary note on aragonite in the Middle Lias has not prematurely precipitated that of his earlier research upon the matter from a more general point of view.

All geologists will be grateful to Professor Cole for giving the world at large so full and well-digested a summary of the chemical side of the question, as well as the result of the tests advocated applied to the shells within his immediate purview (at Dublin) from an extensive range of the geological formations.

The object of these remarks is not to "go one better" than the paper alluded to, but to clarify some misconceptions of my own and others and to set the question upon a firmer and sounder basis for future research.

By the term 'aragonite shells' it would appear that not only have we (1) the shell before fossilization, exhibiting typical aragonite characteristics, but also (2) the presumed former occurrence of it in a fossil shell when the fossil is found to-day as a cast, or (3) replaced by a granular form of calcite. Lastly, we have (4) the known occurrence of certain classes of shells now as aragonite shells in a fossil state.

(1) Dr. Sorby [1] gave a full summary of recent characters of the shell-wall of recent shells, and it has been assumed that this applies to fossil shells as well (though forgotten, as we shall see). The classes he recognized as respectively exhibiting the specific gravity of calcite or aragonite were thus summarized in a paper by Professor P. F. Kendall.[2] They are contrasted here with a table given later—

Calcite.	Aragonite.
Foraminifera.	Corals (but Alcyonaria partly, Hydrozoa mainly aragonite).
Annelids.	Cephalopods.
Echinoderms.	Gasteropods (except *Patella*, *Fusus*, *Littorina*, *Purpura*, etc.).
Polyzoa (containing also some aragonite).	Conchifera (except *Ostrea*, *Pecten*, and outer layer of *Spondylus*, *Pinna*, *Mytilus*).
Brachiopoda.	
Ostrea and *Pecten*.	
Cirripedia and all other Crustacea (the former exhibiting also some aragonite and phosphate of lime, the latter some phosphate).	

(2) Sorby alluded to the occurrence of aragonite shells as *casts* in limestone.[3] But whereas limestones are more usually composed of calcite than aragonite, there are more calcite shells than the latter. In rocks of clastic origin, e.g. the Coralline Crag, casts occur commonly, and the shells belong mainly to the groups whose shell, when the animal was alive, was of aragonite, according to the above scheme. Professor Kendall gave a full list of these.[4] In the paper on the Middle Lias referred to [5] I gave a short list of a few genera which very frequently occur as casts. It is hoped to extend this and other

[1] Presidential Address Geol. Soc., 1879, pp. 29–30, reprint.
[2] Geol. Mag., 1883, p. 497.
[3] Presidential Address Geol. Soc., 1879, p. 35.
[4] Geol. Mag., 1883, p. 498.
[5] Ibid., 1910, p. 175.

details as to the nature of the shell-layer when preserved in specific instances in a later communication. The causes assigned for the occurrence of shells *once possessing an aragonite shell-layer*[1] are recognized by me (ibid., pp. 175, 177) as due to the causes assigned to their decomposition in other beds by Professor Kendall[2]—(*a*) enclosure in permeable beds, (*b*) flow of carbonated water. The latter cause was not alluded to directly by me, but is really an adjunct or necessary outcome of (*a*). Further important remarks on the occurrence of shells once possessing an aragonite shell-layer are given by Professor Kendall and Mr. Cornish in the valuable paper quoted (*antea*). Apparently the term 'aragonite shells' was used by these authors in a wide sense in this paper, for the existence of shells with an aragonite layer in the Coralline Crag is alluded to, and this term probably in the first paper (Geol. Mag., 1883, p. 497) did duty for both. I must plead guilty in my own previous paper to a similar loose terminology (to be corrected *infra*). That Professor Kendall used the term without applying any other distinction than the prefix 'actual' to those still retaining the aragonite test alongside of shells without any present shell-layer (in the rocks) is clear. Possibly the use of the term has been due to the sanction of the term by Sorby, who uses it for recent shells and rather often in his address (Geol. Soc.), whilst he also recognizes the occurrence of these same groups as casts in the rocks and also with the aragonite now converted into calcite.

Moreover, it appears that by the use of the terms 'aragonite Mollusca' and 'aragonite shells' in Lias (p. 54), in Great Oolite (p. 53), and in Cornbrash (p. 51) and Cleveland Ironstone (p. 54), 'calcite organisms' in Oolites (p. 53), 'calcite Mollusca' (p. 52), 'calcite Polyzoa' in Portland Oolite (p. 50), 'aragonite shells' in Purbeck Limestone (p. 49) and Chalk (p. 48), 'calcite shells' in Kentish Rag (p. 49), Sorby intended to convey the idea that they belonged to a type in which to-day the shell is characterized by being composed of either calcite or aragonite. In these passages he says nothing as to their mineral structure at the period cited, which he examined. It appears, indeed, that it has been left to later observers to point out what shells still retain the aragonite layer. But in the following passages the terms are used with accompanying indications of their state at the time of examination (he of course makes *general* statements as to the state of the calcite or aragonite in the fossil state compared with its original structure), viz., under Tertiary limestones he writes: "Being aragonite shells they have usually been removed or changed into crystals of calcite," and as to the Barton Clay, "that of the various Gastropoda, composed of aragonite, is as perfect as in living shells." This surely means that Sorby had in his mind Barton Clay Gasteropods, in which the shell was aragonite originally when the animal was alive, and when he examined it *also*, or unaltered. Surely Professor Cole cannot hesitate to accept this, though he says it is not clear that Sorby meant to assert this. I think this is the clearest passage in which Sorby indicates that the shells he examined were *still* aragonite.

[1] As we shall see, this is the correct way to describe aragonite shells.
[2] Geol. Mag., 1888, p. 68.

And again he wrote (p. 49) "freshwater shells of the aragonite type" in referring to the Wealden limestones, showing that he had in mind their first, not fossil condition.

As to *pre*-Jurassic formations, he writes (p. 56) of the Carboniferous Limestone of "fragments of what were probably aragonite organisms" as "now quite crystalline", and "show no structure", and (p. 57) as to the Devonian limestones "completely disintegrated aragonite organisms", and under Silurian limestones as to the Upper Ludlow rock (p. 60) of "some portions of what were probably aragonite shells", and "few or no fragments of organisms not originally calcite", and in the case of Aymestry Limestone of 'aragonite shells', in connexion with Wenlock Limestone, of "recrystallized fragments of aragonite shells". Thus, as Professor Cole remarks, it is apparently the case that in rocks of pre-Jurassic age we cannot expect shells to consist of aragonite (Geol. Mag., 1911, p. 49).

This use of the terms as applied to mineral states of shells not identical with their original state is to be regretted, and I have therefore (*infra*) drawn up a nomenclature which I hope will prevent any confusion in the future.

Professor Cole, in his *Aids to Practical Geology*, 1902, p. 201, distinguishes shells as 'aragonite shells' and 'calcite shells'. That he deserves the credit for introducing a clearer nomenclature for these various stages is obvious from the attention he has drawn to my own loose use of terms and the present attempt to improve on them. I would say here, however, that the expression "preserved in aragonite" (p. 76 of my paper) should be taken as correct, but that for the words just above, "when preserved as fossils," should be substituted "the recent shells are of", and lower down "if not removed by decomposition". For the list given by Sorby deals with the types of shell in living shells, and the comparison made with fossil types will not hold good all round, since, as pointed out by Dr. Sorby, Professor Cole, and others, the aragonite is often replaced by calcite as a granular pseudomorph. This false parallel has probably caused the artificial division into calcite and aragonite shells, apart from (1) alteration in the shell-substance or (2) possibility of different shell-layers in the same shells.

That I had no real reason for confusing the two classes of shell-structure present and past is illustrated by the passages (ibid., p. 174) "to the parts of shells which have not been converted into calcite", (ibid., p. 175) "all have the outer original aragonite layer removed, and are preserved as casts", and (p. 177) "aragonite as the replacing mineral", but here 'replaced' should be read for 'replacing'. So much by way of correction of slipshod terms, which I am the less unwilling to admit because I am not the sole offender!

(3) When the shell neither exhibits an aragonite layer nor an *original* calcite layer, and is not a mere cast, it may be preserved as a shell with the *original* aragonite layer replaced by calcite of a granular character. Rose, in 1858, suggested that shells found as casts were originally of aragonite, those still preserved of calcite. Sorby further (ibid., p. 35) remarks on the transformation of aragonite into calcite: "when the aragonite shells are still represented by

a distinct calcareous layer, this has no longer the original structure, but is more or less coarsely crystalline, and quite unlike the contiguous calcite shells which still retain their original microscopical and optical characters."

Professor Cole (ibid., p. 50) has referred to the passing of aragonite into calcite in the fossil state, and the record of fossils he gives, where the shell-layer is determined as calcite in the case of those originally possessing an aragonite test, forms the nucleus of our specific enumeration of such cases. In the table here appended additional instances are given.

(4) The occurrence of aragonite in the shell-layer of fossil shells and other organisms is definitely remarked upon by Sorby (ibid., p. 47) in regard to the Barton Clay. Messrs. Kendall and Vaughan Cornish refer to actual aragonite shells (ibid., p. 68) in the Coralline Crag, species of *Fusus* (p. 70), Cephalopoda from the Cretaceous, *Belemnitella*, *Artemis lentiformis*, and in *Eschara* an inner calcite and an outer aragonite layer. They state (p. 72) that "the Mollusca always have the aragonite layer internal". But this is not so, for in *Nautilus* it is external, as in all Ammonites. The aragonite nature of porcellanous Foraminifera is referred to and their absence in certain formations noted, though the other group *Vitrea* occurs, being explained by the supposition that they have disappeared or been obliterated, being represented only as casts, which give no indication of their former existence.

In my paper on the occurrence of aragonite in the Middle Lias I have given instances of aragonite shells still preserving their test unaltered. Further, Professor Cole has collected cases of the occurrence of aragonite shell-layers in fossil shells from Jurassic to Recent times, and he admits the occurrence of these in the Lias, adding (ibid., p. 55) that I "may be justified in expecting some retention of aragonite even in Jurassic strata", though in his opening remarks he asks the question whether they are preserved (evidently meaning now) in aragonite, a question he answers for himself, in other instances affirmatively, *en passant.*

So far we have considered the question, almost exclusively, as though only *one* shell-layer (*either* calcite *or* aragonite) existed in fossil shells, regardless of the admitted existence of more than one layer in both Lamellibranchs and Cephalopods. And though incidentally Messrs. Kendall and Cornish refer to two distinct layers in one shell (*ante*), this is apparently the only gleam of light upon the question in all previous research on the shell-layer of fossil molluscs (I should not omit to say that Bather and Hyatt fully recognized this in writings in reference to structure, apart from fossil preservation). For previously everyone, though admitting (tacitly) the homology between the structure of recent and fossil shells, has ignored the triple or double character of the former in stating conclusions as to the chemical composition of the latter.

In the following table we give a summary of the nature of the shell-layer in the different groups of Mollusca, living and fossil, for comparison, omitting for present purposes those exceptions in both Gasteropoda and Lamellibranchiata in which the shell-layers do not conform to the usual type, e.g., *Patella*, *Fusus*, *Littorina*, *Purpura* in Gasteropoda, *Ostrea*, *Pecten*, *Chama*, *Spondylus*, *Pinna*, *Mytilus* in Lamellibranchiata.

Group.	Living.	Fossil.
Gasteropoda . .	*Only layer.* Aragonite, with chitinous substance (conchiolin), rarely sulphate of lime.	*Only layer.* Aragonite, usually found as casts, but sometimes as aragonite, sometimes granular calcite.
Lamellibranchiata .	1. Outermost layer dark, horny conchiolin. 2. Outer prismatic calcareous layer of calcite. 3. Inner layer, lamellar porcellanous aragonite.	1. Absent. 2. Calcite. 3. Aragonite, usually pseudo-calcite.
Cephalopoda . .	1. 'Black layer.' 2. Porcellanous laminar aragonite. 3. Nacreous calcite.	1. 'Black layer' (rare). 2. Aragonite. 3. Aragonite.

I am quite aware isolated instances (and even published figures, e.g. Hyatt's) have been given of separate layers in fossil shells, but the prevailing custom has been to treat them as one, and as calcite *or* aragonite, never both. The very names 'aragonite shells', 'calcite shells' show the laxity into which we have fallen. The addition of a nacreous layer in Lamellibranchs and Cephalopods is an argument in favour of their derivation from Gasteropods, and not vice versa.

Since there is some confusion in the use of the terms calcite and aragonite shells applied to fossil shells, I have drawn up below a table of terms and states which may be useful in avoiding the confusion inevitable unless the present state and age are both stated parenthetically with each separate use of either names, and as a name, even if it is a bad one, is better than a parenthesis, we offer the following terminology as a beginning in this direction, incorporating existing ones that are easily intelligible.

Terms.	Layer.	Condition or Age.
Calcite.	Inner.	Living.
Aragonite.	Outer.	,,
Authocalcite.	Inner.	Fossil unaltered.
Mesauthocalcite.	Middle.	,, ,,
Autharagonite.	Outer.	,, ,,
Pseudo-calcite.	,,	Fossil altered.
Mesopseudo-calcite.	Middle.	,, ,,
Atestous cast.	Inner or outer.	Fossil.
'Black layer.'	Third layer.	Living or fossil.
Epidermis or periostracum.	,,	Living (rare in fossil state).

Genera and Species.	Formation.	Locality.
Gasteropoda.		
1. *Pseudomelania turbinata* (Stol.)	Middle Lias	Chipping Warden
2. ,, ,,	,,	Pickwell
3. ,, ,,	,,	Tilton
4. ,, ,,	,,	Pickwell
5. *Amberleya imbricata* (Sow.)	,,	Grimston
6. *A. undulata* (Phill.)	,,	Thorpe Satchville
7. *A.* ,, (Phill.)	Lower Lias	Great Dalby
8. *A. elegans* (Münst.)	,,	Old Dalby
9. *A. dunkeri* (Münst.)	,,	Ingarsby
10. *A. gaudryana* (d'Orb.)	Middle Lias	Tilton
11. *Turbo latilabrus* (Stol.)	,,	Pickwell
12. *T. brannoviensis*, Wilson	,,	,,
13. *Trochus northamptonensis*, Wilson	,,	Tilton
14. *T. thetis*, Münst.	Lower Lias	Old Dalby
15. *T.* sp.	Middle Lias	Neville Holt
16. *T. ariel*, Dum.	,,	Tilton
17. *T. lineatus*, Moore	,,	Chipping Warden
18. *T. ziziphinus*, Linn.	Coralline Crag	Ramsholt
19. *T. subexcavatus*, S. Wood	,,	Orford Castle
20. *T. adansoni*, Payr.	,,	Sutton
21. *T. papillosus*, Da Costa	Red Crag	Walton-on-Naze
22. *Scalaria foliacea*, Sow.	Coralline Crag	Sutton
23. *S. clathratula*, Tate	,,	,,
24. *Chemnitzia blainvillei* (Münst.)	Lower Lias	Old Dalby
25. *C. citherella*, Tate	,,	,,
26. *C. internodula*, S. Wood	Coralline Crag	Orford Castle
27. *Solarium plicatum*, Lam.	Barton Beds	Barton
28. *Capulus sinuosus*	Pliocene	Parma
29. *Natica labellata*, Lam.	Barton Beds	Barton
30. *Coplostylus brevis* (Sow.)	Headon Series	Hordwell
31. *Cerithium ibex*, Tate	Lower Lias	Old Dalby
32. *C. camertonense*, Moore	,,	,,
33. *C. liassicum*, Moore	,,	,,
34. *C. ferreum*, Tate	Middle Lias	Tilton
35. *C. confusum*, Tate	,,	,,
36. *C. reticulatum*, Desl.	,,	,,
37. *C. subscalariforme*, d'Orb.		
38. *C.* var. *spinicostata*, Wright MS.		
39. *Turritella trigemmata*, Tate	Lower Lias	Old Dalby
40. *Actæonina ilminsterensis*, Moore	Middle Lias	Tilton
41. ,, ,,	,,	Chipping Warden
Lamellibranchiata.		
42. *Nucula emarginula*	Pliocene	Parma
43. *N. variabilis*, Sow.	Lower Lias	Old Dalby
44. *Leda equilatera* (Koch & Dunker)	,,	,,
45. *L. galathea* (d'Orb.)	,,	Great Dalby
46. *Cucullæa munsteri*, Ziet.	,,	Leicester

Layers. Inner. (1)	Middle. (2)	Outer. (3)	Remarks.
1. Cast			The usual state.
2. ,,			,, ,,
3. Calcite			The only layer, entirely converted.
4. ,,			The only layer, partly converted.
5. ,,			
6. ,,			Opaque white.
7. Pyritized			Opaque.
8. Aragonite			Dull white opaque.
9. Granular calcite			
10. ,,			Entirely converted.
11. Cast			And (1) partly calcite.
12. ,,			
13. Calcite			
14. Aragonite			
15. Calcite			Opaque white.
16. ,,			
17. Cast			
18. Aragonite			Opaque white.
19. ,,			,,
20. Calcite			Slightly iridescent.
21. ,,			,, ,,
22. ,,			Yellow, translucent.
23. ,,			,, ,,
24. Aragonite			With casts also.
25. ,,			(1) Opaque white, but nearly entirely a cast.
26. Calcite			
27. ,,			Dull opaque, white.
28. ,,			Opaque white.
29. ,,			Dull opaque, reddish-white.
30. ,,			
31. Aragonite			And (1) a cast.
32. Aragonite and Calcite			,, ,,
33. Aragonite			
34. Calcite			Semi-translucent, white, whole shell.
35. ,,			Semi-translucent, white.
36. ,,			Whole shell translucent.
37. ,,			Whole shell.
38.			
39. Aragonite			
40. Granular calcite			And as casts.
41. Casts			
	Remaining outer layer in this group (when fossil)		
42. Calcite	Calcite		Yellowish, semi-translucent.
43. Aragonite			Dull, only layer.
44. ,,			Whitish-yellow.
45. ,,			,,
46. ,,			,,

Genera and Species.	Formation.	Locality.
47. *Arca liasina*	Middle Lias	Cheltenham
48. *A. buckmani*, Rich.	,,	Gloucestershire
49. *Pectunculus glycimeris* (Linn.) . .	Red Crag	Butley
50. *Perna maxillata*	Miocene	Basle
51. *Inoceramus ventricosus*, Sow. . .	Middle Lias	Cheltenham
52. *I. concentricus*, Park.		
53. *Gryphæa arcuata*, Lam.	Lower Lias	Lincoln
54. *Lima gigantea* (Sow.)	,,	Barrow-on-Soar
55. *Amussium lunularis* (Römer) . .	Middle Lias	Tilton
56. *Pecten orbicularis*, Sow.	Upper Greensand	Warminster
57. *Modiola scalprum*, Sow.	Lias	Leicestershire
58. *Pholadomya koninckii*, Nyst. . .	Thanet Sands	Isle of Thanet
59. *Cypricardia cucullata* (Münst.) . .	Middle Lias	Chipping Norton
60. *Astarte striato-sulcata*, Römer . .	Lower Lias	Great Dalby
61. *A. compressa* (Mont.)	Chillesford Beds	Chillesford
62. *Cyrena cuneiformis* (Sow.)	Woolwich Beds	Charlton
63. *C. pulchra*, Sow.	Bembridge Beds	Isle of Wight
64. *C. cordata*, Morris	Woolwich Beds	Charlton
65. *Cardita sulcata* (Brander) . . .	Barton Beds	Barton Cliff
66. *Unicardium cardioides*, Phil. . .	Middle Lias	Cheltenham
67. *Corbis lamellosa*, Lam.	Tertiary	Gisors
68. *Cardium edule*, L., var. *umbonatum* .	Norwich Crag	Bramerton
69. *Dosinia lentiformis*, Sow.	Red Crag	Walton
70. *Venus rugosa*, Flem.	Pliocene	Parma
71. *V. brongniarti*, Payr.	,,	,,
72. *Protocardium truncatum*, Sow. . .	Middle Lias	Chipping Norton
73. *Cytherea erycinoides*	Calcaire Grossier	Ronca
74. *Corbula ficus* (Brander)	Barton Beds	Barton
75. *C. striatula*, Sow.	Gault	Folkestone
76. *C. pisum*, Sow.	Barton Series	Barton
Cephalopoda.		
77. *Nautilus centralis*, Sow.	London Clay	Middlesex
78. *Baculites ovatus*, Say	Upper Chalk	Dakota
79. *Scaphites nodosus*, Owen	,,	,,
80. *Psiloceras planorbe* (Sow.)	Lower Lias	Watchet
81. *Coroniceras sauzeanum* (d'Orb.) . .	,,	Glen Magna
82. *C. bucklandi* (Sow.)	,,	Leicestershire
83. *Vermiceras conybeari* (Sow.) . . .	,,	Kilby
84. *Arnioceras semicostatum* (Y. & B.) .	,,	Evesham
85. *Hildoceras bifrons* (Brug.)	Upper Lias	
86. *Grammoceras serpentinum* (Rein.) . .	,,	Yorkshire
87. ,, ,, . .	,,	Lincoln
88. *Ludwigia cornu* (S. Buckm.) . . .	Inferior Oolite	Bradford Abbas
89. *Paltopleuroceras spinatum* (Brug.) .	Middle Lias	Yeovil
90. *Amaltheus margaritatus*, Montf. . .	,,	Saltburn

	Layers. Inner. (1)	Middle. (2)	Outer. (3)	Remarks.
47.	Calcite			Whitish-yellow.
48.	Aragonite			
49.	Calcite	Calcite		(2) Dull white.
50.	,,			White.
51.	,,	Calcite		(2) Opaque brown, (1) white.
52.	,,	,,		(1) White, (2) dull red.
53.	,,			Translucent grey.
54.	,,			Dull black.
55.	,,			Translucent white.
56.	Aragonite	Calcite		(1) White, (2) dull brown.
57.	Calcite			Dull brown, translucent.
58.	Aragonite	Calcite		(1) White, (2) dull pinkish-white.
59.	Calcite	,,		(1) Dull white, (2) pinkish-white.
60.	Aragonite			Opaque, dull white.
61.	Calcite			Brownish-yellow.
62.	,,			Opaque white.
63.	,,			
64.	,,			White.
65.	,,			
66.	Aragonite	Calcite		(1) Opaque, dull white, (2) opaque brownish-white.
67.	Calcite			Pure white.
68.	,,	Calcite		(1) White, (2) dull brown opaque.
69.	,,	,,		,, ,, ,,
70.	,,	,,		(1) and (2) pinkish-white.
71.	,,	,,		
72.	,,	,,		(1) and (2) dull brown.
73.	,,			Dull chalky-white.
74.	,,	Calcite		
75.	Aragonite			
76.	Calcite	Calcite		
77.	Calcite	Calcite		(1) Opaque, (2) brown.
78.	,,	,,	Calcite	(1) Translucent brown, thick, (2) thin iridescent, (3) brown translucent, thick.
79.	,,			Iridescent, translucent, aptychus also calcite.
80.	,,	Calcite		(1) Dirty brown, iridescent, (2) white.
81.	,,	,,		(1) Brown, (2) pyritized.
82.	,,	,,		
83.	,,			Dull yellowish-brown, thin, slightly translucent.
84.	,,	Calcite		(1) Translucent, (2) dark brown.
85.	,,	Aragonite		(1) Dark brown, (2) light creamy-brown, opaque.
86.	,,	,,		(1) Pyritized, (2) dark brown.
87.	,,	,,		(1) Pyritized, (2) opaque white, powdery.
88.	,,			Translucent, yellow.
89.	,,			Translucent.
90.	,,	Calcite		(2) Opaque brownish-white.

Genera and Species.	Formation.	Locality.
91. *Amaltheus margaritatus* (Montf.)	Middle Lias	Crick
92. *A. ibex* (Quenst.)	,,	Cheltenham
93. *Amblycoceras capricornum* (Schloth.)	Lower Lias	Lyme Regis
94. ,, ,,	Glacially derived from Lias	Leicester
95. *Tropidoceras exaratum* (Y. & B.)	Upper Lias	Stroud
96. *Acanthopleuroceras valdani* (d'Orb.)	Lower Lias	Old Dalby
97. *Deroceras armatum* (Sow.)	Middle Lias	Whitby
98. *D. subplanicosta* (Opp.)	Glacially derived	Leicester
99. *D. planicosta* (Sow.)	Lower Lias	Robin Hood's Bay
100. *Dactylioceras commune* (Sow.)	Upper Lias	Whitby
101. *Perisphinctes triplex* (Sow.)	Kimmeridge Clay	Weymouth
102. *Hoplites denarius* (Sow.)	Gault	Folkestone
103. *H. tuberculatus*, Sow.	,,	,,
104. *Anahoplites splendens* (Sow.)	,,	,,
105. *Crioceras plicatile* (Phil.)	Neocomian	Speeton
106. *Hamites maximus*, Sow.	Speeton Clay	Filey
107. ,, ,,	Gault	Folkestone
108. *H. attenuatus*, Sow.	,,	,,
109. *Cosmoceras jason* (Rein.)	Oxford Clay	Christian Malford
110. *Ancyloceras spinigerum*, J. de C. Sow.	Gault	Folkestone
111. *Belemnites owenii*, Pratt, var. *puzosianus*, d'Orb.	Oxford Clay	Peterborough
112. *Belemnites* sp.	Lias	Northamptonshire

In order that there may be, further, no need to confuse the nature or composition of the shell-layers of either fossil or recent shells, we give below some of the differences or tests that serve to distinguish the two forms of carbonate of lime in shells.

Character or Test.	Aragonite.	Calcite.
Specific gravity	2·94 to 3	2·72
Hardness	3·5 to 4[1]	3
Lustre	Opaque	Translucent
Composition—		
Carbonic acid	—	42·2
Carbonate of lime	98·02	54·4
Carbonate of strontium	·99	—
Protoxide of iron	—	1·55
Peroxide of iron	·11	—
Silica	—	1·85
Water	·17	—
	100	100
With solution of cobalt nitrate	Turns lilac	No reaction

[1] An aragonite shell will scratch a calcite shell.

	Layers.			Remarks.
	Inner. (1)	Middle. (2)	Outer. (3)	
91.	Calcite			Opaque white.
92.	(?)	Aragonite		,,
93.	Calcite	Calcite		(2) Opaque white.
94.	,,	,,		(2) ,,
95.		,,		(2) ,,
96.	Pyritized	,,		(2) ,,
97.	,,	,,		(2) Opaque pinkish-cream.
98.	,,	,,		(2) Opaque pinkish-white.
99.	,,	,,		(2) ,, ,,
100.	,,	,,		(2) Dark brown, translucent.
101.		,,		Iridescent, opaque, pinkish-white.
102.	Pyritized	,,		(2) Opaque white.
103.	,,	,,		
104.	,,	,,		(2) Pinkish-white.
105.		,,		(2) Opaque white.
106.	Pyritized	,,		(2) Opaque pinkish-white.
107.		,,		Iridescent.
108.	Pyritized	,,		
109.	,,	,,		
110.	,,	,,		
111.	Calcite			
112.	,,	Calcite		Conotheca and phragmocone both calcite, pyritized within.

In order to give some notion of the variability of the structure of the shell-layer in a typical collection of molluscan fossil shells, I have endeavoured to indicate above (pp. 412–17) the characters of the species represented in the palæontological collections in the Invertebrate Department of Leicester Museum arranged biologically.

As this collection exhibits allied genera in proximity, it serves better for this purpose, which is essentially a biological investigation, than a study of the same material arranged stratigraphically. I might have undertaken to examine the shell-layers in the stratigraphical collection, but as its arrangement has only just been completed *pro tem.*, and it requires to make it complete a good deal more material,[1] I have left that till later. The following list, however, contains a representative series of genera, and in some cases species identical with those enumerated by Professor Cole, with varying results. The few cases in which aragonite still remains unaltered are sufficiently rare to warrant the assumption that its preservation is exceptional in Jurassic time, and though of more frequent occurrence in some places in Tertiary time is still less common in the intervening Cretaceous period.

[1] Any geologist who has duplicates may contribute towards this desideratum if he or she will.

Out of a total of 101 species, twenty-four have a shell-layer of aragonite—

Gasteropoda . . .	10	(inner and only layer).
Lamellibranchiata . .	10	(inner of two layers).
Cephalopoda . . .	4	(outer of two layers).
	24	

In none of the Cephalopoda recorded above is a third or 'black layer' present, but an example of *Nautilus striatus*, Sow., from the Lias is contained in the same collection possessing this in a very good state of preservation. In *Baculites* an extraordinary thick shell exhibits three distinct layers all of calcite, but the middle one was originally aragonite like other Cephalopods. Of the Cephalopods with an aragonite layer one is a Middle Lias and three are Upper Lias forms. Amongst the Gasteropods which still retain an aragonite layer eight come from the Lower Lias and all but one from the same locality, Old Dalby, whilst two are Coralline Crag species. The proportion of casts in this group is much larger than in Lamellibranchiata or Cephalopoda. There is, moreover, apparently a geographical limit to the persistence of aragonite in the same formation, as illustrated by the Old Dalby species. There is no restriction of it to certain generic types, though it is found most often in the genera *Amberleya*, *Trochus*, *Chemnitzia*, *Cerithium*, and *Turritella*, and amongst these in *Trochus* and *Cerithium* especially, though here allied species are not uniformly preserved as aragonite now.

Amongst Lamellibranchs two species from the Middle Lias are preserved as aragonite; five are from the Lower, and one species of each come from the Upper Greensand, Gault, and Thanet Sands respectively.

In the Lower Lias *Nucula*, *Leda*, *Cucullæa*, and *Arca* in the Middle Lias appear to be especially associated with an aragonite inner layer.

Thus, in the main, the contentions advanced by Professor Cole hold good in a second series of observations made by me independently, whilst my original suggestion as to aragonite being still the shell-layer in Middle Lias forms is borne out by additional examples and further strengthened by the abundance of Lower Lias types.

NOTICES OF MEMOIRS.

The Baluchistan Earthquake of 21st October, 1909. By A. M. Heron, B.Sc., F.G.S. Records, Geological Survey of India, vol. xli, pp. 22–35, 1911.

THE earthquake (of intensity 9, Rossi-Forel scale) occurred at about 5.12 a.m., in a district from 40 to 50 miles to the north of Jacobabad, and resulted in the loss of 231 lives and much damage to the villages of Bagh, Bellpat, and Shahpur. As in most strong earthquakes, the onset of the shock was sudden. Mr. Heron traces three isoseismal lines from the evidence of damaged buildings. They are remarkable for their great elongation from north-west to south-east, the innermost being 57 miles long and only 8 miles wide. The central area is covered by thick alluvial deposits, but it lies in the gigantic festoon of the Marri and Bugti Hills, by which the north and south trend of the Baluchistan ranges is interrupted. Mr. Heron considers that the earthquake was probably caused by a movement along a reversed fault, although no trace of deep-seated displacement is visible at the surface. C. D.

REVIEWS.

I.—Geology of Thouars.

La Géologie des Environs de Thouars (Deux-Sèvres) et l'Etage Toarcien. By Professor Jules Welsch, of the University, Poitiers. Mém. Soc. des Sc. Nat. des Deux-Sèvres, 1911.

THE rocks of this district include, as a foundation, Pre-Cambrian schists and granitic rocks, and then Toarcian, Bajocian, Bathonian, Callovian, Cenomanian, Turonian, and various Quaternary deposits. Attention is directed especially to the Toarcian of Thouars or *Toarcium*, where the classic section as seen in the quarries at Vrines shows in downward succession: Plateau deposits ($1\frac{1}{2}$ metres), Cenomanian ($\frac{1}{2}$ metre), Toarcian (conglomerate and grit, blue marls, ferruginous oolites, yellow marls and limestones, about 10 metres), Pre-Cambrian (schists and slates).

The Toarcian strata (as originally grouped by d'Orbigny) are divided into the following zones or palæontological horizons by Professor Welsch:—

Ammonites opalinus (with *Rhynchonella cynocephala*, *Terebratula infra-oolithica*, etc.).
A. aalensis (with *Dumortieria Moorei*, etc.).
A. radians (with *Catulloceras dumortieri*, etc.).
A. insignis (with *Grammoceras fallaciosum*, etc.).
A. toarcencis (with *G.* cf. *striatulum*, etc.).
A. variabilis (with *Lytoceras sublineatum*, etc.).
A. bifrons (with *Dactyloceras holandrei*, etc.).
A. falcifer (with *D. annulatum*, etc.).

The conglomerate and grit (1 to 3 metres thick) which rests irregularly on the Pre-Cambrian was at one time grouped with the Middle Lias, but Professor Welsch, after prolonged research, found in the strata an ammonite near to *Harpoceras Strangewaysi*, and he groups the beds with overlying layers in the zone of *Ammonites falcifer*.

He remarks that there is a gradual passage from one zone to another in the Toarcian of Thouars, and that the type of the stage has been well chosen in the quarries of Vrines–Thouars, where there occur neither the Ammonites of the Middle Lias nor those of the Bajocian.

After commenting on the Aalenian division of Mayer-Eymar, Professor Welsch observes that there are affinities between the beds with *Lioceras opalinum* and those with *Ludwigia Murchisonæ*, while again it is difficult to separate the higher zonal stages in the Bajocian, the divisions being arbitrary and local.

II.—Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for 1910. pp. iv, 87, with 6 text-illustrations. London: printed for H.M. Stationery Office, 1911. Price 1*s.*

During the past year the Geological Survey in England and Wales have been engaged in mapping portions of the coal districts of Flintshire, Denbighshire, Warwickshire, and South Staffordshire, and some of the agricultural and residential areas of Berkshire, Buckinghamshire, and Surrey, with the object of completing the six-inch survey of the London district and the south-east of England. In the Welsh district the subdivisions of the Carboniferous rocks have been mapped in detail, and certain red sandstones and marls, formerly grouped as Permian, are now placed with the Upper Coal-measures. A good deal of fresh information regarding the Glacial drifts and newer deposits has been gathered. In Warwickshire and South Staffordshire new information has been obtained on the structure, the faults, and the upper red barren measures of the coal-fields, and an account is given of bands of calcareous concretions in the Keuper Sandstone that resemble conglomerate and have been so described in the record of a boring. The glacial deposits comprise a Western Drift, composed chiefly of Bunter material, and an Eastern Drift, with Chalk flints, etc.

In the account of work done in the London and South-Eastern district there is a new and important record of a deep boring at Ottershaw Park, which has been carried through Bracklesham Beds to a depth of 1,556 feet, the base of the Gault not having been reached. The details are of great interest, inasmuch as after penetrating 40 feet of ordinary Upper Chalk the bore-hole was carried through 211 feet of Eocene clays and sands mixed with chalk and flints, after which solid chalk was again reached. The disturbed beds seem to have been met with along a nearly vertical fissure. The greywethers and Drift on the Chiltern Hills are well known.

In Scotland field-work has been carried on in Mull and South Morvern, in the counties of Sutherland, Perth, and Inverness, and in the central coal-fields. A collection of fossil plants from the Carboniferous rocks, discovered by Professor Judd at Morvern, has been examined by Dr. Kidston, and the species indicate that the strata are of approximately the same age as the productive Coal-measures of Central Scotland. Evidence of Rhætic beds has been found in Morvern, and some account is given of the Lower Lias and Cretaceous rocks of that region. Good progress has been made in mapping the Tertiary igneous rocks of Mull, and it is observed that the Tertiary coals of the island are of little economic value. In the North and Central Highland district the work has been continued among the metamorphic and associated igneous rocks, including the Lewisian and Moine types, but the relations between these have not yet been definitely established. In the Central Coal-field the revision of the Lower and Upper Carboniferous rocks has been carried on in the districts of Shotts, Fauldhouse, Carluke, East Kilbride, and Douglas. Many new facts are recorded, notably the list of fossils from the

Calciferous Sandstone in the East Kilbride district, where a Pendleside fauna, with *Posidonomya Becheri*, *Pterinopecten papyraceus*, and other species, has been discovered.

III.—Swedish Geological Survey.

A Swedish Pre-Glacial River.

In the recently issued Year Book of the Swedish Geological Survey for 1910, Dr. Nils Olof Holst, under the title "Alnarps-Floden en Svensk 'Cromer-Flod'", publishes an account of a large river of pre-Glacial age, which he believes to have run right across the southern part of Scania in a N.W.–S.E. direction, serving as the outlet for a large part of the southern Baltic and of northern Germany, and thus playing much the same part as the Sound and the Belts do now. This river-bed, which runs not far from the town of Malmö, is filled with thick river deposits and forms a natural water-basin of artesian character. Therefore, for the purposes of Malmö's water supply, the deposits have been pierced by a large number of borings, and, especially of recent years, a large amount of information has been collected concerning them and their included fossils. The paper gives a detailed account of the sections found at different borings, as well as a complete list of fossils. The general conclusion is that the main river deposit is of about the same age as the Cromer forest-bed and a little later than the *Cyprina* clay of northern Germany. These deposits are very rich in amber, which seems to show that the river must have come from the home of amber in the province of East Prussia. In this case it must have flowed over the region where the southern Baltic now is, and that region must then have been in the main dry land. The various changes of level to which the observed phenomena point are thus summarized by Dr. Holst: "The ice period was preceded and introduced by an elevation of the primitive Scandinavian massif, correlated with a depression where the southern Baltic now lies. It was during this depression period that the *Cyprina* clay was deposited. During the next stage, after the inland ice had been piled up in northern Sweden and perhaps also over part of middle Sweden, this ice exercised such a pressure on the primitive massif that the whole region outside of it, that is to say, southern Sweden and northern Germany, was pressed up. This is the Cromer period or the pre-glacial, north European, mainland period. It was then that the pre-glacial rivers hollowed out and filled their beds. Finally, when the inland ice approached the southern Baltic, there took place here a fresh depression, and for a short period an arm of the sea stretched in again right up to East Prussia, to be speedily covered up by the still ever-advancing ice. It was in this gulf that the pre-glacial *Yoldia* clay of Prussia was deposited. In the same way, as the inland ice retreated from the southern Baltic district, there occurred first a depression, the late glacial, corresponding to the previously mentioned pre-glacial; then an elevation, the well-known post-glacial, the mainland period of northern Europe; and finally the last depression, that of the *Litorina* period corresponding to the pre-glacial *Cyprina* clay period." Dr. Holst believes that the river-beds already discovered indicate a heavy rainfall at the close of the Tertiary era, and that there must have been many such large rivers, whose beds and courses remain to be discovered by the geologists of the future.

IV.—Geological Survey of India.

An essay on "The Geology of the Andaman Islands, with references to the Nicobars", by Mr. G. H. Tipper (Mem. Geol. Surv. India, vol. xxv, pt. iv, 1911), contains two colour-printed maps of the three islands on the scale of 1 inch to 4 miles. The middle island was not explored, "on account of the wild Jarawa tribe." The formations represented are Upper Cretaceous serpentines, Eocene conglomerates and sandstones, Miocene limestones, shell marls, and Foraminiferal sands, also Miocene (?) beds with Radiolaria, and Recent mangrove swamps. In addition there are some scattered exposures of quartzites, jaspers, and porcellanic limestones of Pre-Tertiary age, in part Lower Cretaceous, and into these the igneous rocks have been intruded. Coal occurs in pockets in the Eocene sandstones; it is of poor quality, and no sign of a continuous seam has been observed.

In the Records of the Geological Survey, vol. xli, pts. i and ii, 1911, there are accounts of deposits of manganese-ore in the Central Provinces and in Bengal, by Mr. L. L. Fermor; of the Baluchistan earthquake of October 21, 1909, by Mr. A. M. Heron; and of observations in Kashmir, by Mr. C. S. Middlemiss. There are also descriptions, accompanied by two plates, of Devonian fossils from Chitral, Persia, Afghanistan, and the Himalayas, by Mr. F. R. Cowper Reed. In the General Report of the Geological Survey of India, Mr. H. H. Hayden, Director, gives particulars of the work done during 1910, and records the unusually heavy losses caused by the retirement on October 29 of Mr. T. D. La Touche and on November 30 of Sir Thomas H. Holland, the Director.

V.—La Face de la Terre (Das Antlitz der Erde). Par Ed. Suess. Traduit avec l'autorisation de l'auteur et annoté sous la direction de Emmanuel de Margerie. Tome iii, 2e partie. 8vo; pp. xii, 531–956. Avec 2 cartes en couleur et 124 figures dont 101 nouvelles (89 exécutées spécialement pour l'édition française). Paris, 1911. 12 fr.

We have already called attention to the English edition of this work, and the present volume contains the text of the first seven chapters of the English vol. iv (noticed in Geol. Mag., April, 1910, p. 178). The French edition, as indicated in the title, contains many additional illustrations, and it has the advantage also of additional references, some of them to works published this year, and the titles are properly inserted between brackets. In the work of translation M. de Margerie has been assisted by MM. Henri Baulig, Paul Lemoine, and Ch. Jacob.

VI.—Pebbles. By E. J. Dunn. 8vo; pp. 122, 76 plates, containing 250 figures. Melbourne, etc.: Robertson & Co., 1911.

SIR ARCHIBALD GEIKIE, in his shilling Primer of Geology, told the story of a Pebble in perhaps the simplest and clearest language that was possible. Mr. Dunn has amplified this story and told us pretty well all that there is to know about the subject. And his many excellent illustrations range from ordinary pebbles in all their stages to wind-worn stones, impressed pebbles, crushed pebbles, obsidian buttons, and ice-scratched stones. His book has nine pages of double-column index and twenty-six pages of description of plates. It is divided into seven chapters, as follows: Miscellaneous, Forms of Pebbles, Material of Pebbles, Formation of Pebbles, Varieties of Pebbles, Transport of Pebbles, and Uses of Pebbles to Man. Of these chapters we give the heads of chapter iv as illustrative of the treatment:—The Formation of Pebbles.—Mechanical Agencies: Heat and Cold—Wind—Water—Ice—Volcanic Action—Earth Movements. Organic Agencies. Chemical Agencies: Reactions between Rock-forming Minerals — Australites. Plant Agencies. Animal Agencies.

Among the more curious notes in the book are those on Australites, which he says are often water-worn or wind-worn into true pebbles, although their origin is clearly volcanic; and the little piles of stones which seem to be properly recognized as gizzard-stones of dead Moas. In this latter connexion the interesting paper by Mr. W. H. Wickes on Stomach Stones, and the more recent note on a find of a pile of stones said to have come from an elephant, would have been too recently published for inclusion in Mr. Dunn's book. We note a certain amount of repetition which Mr. Dunn would do well to avoid in another edition, and the omission of a Bibliography which would have been of great use to those interested in a side issue of this kind. The book is dedicated to Professor J. W. Judd. The price is not stated.

VII.—The Chief Geological Zones and their Mollusca. By R. Bullen Newton. Being Presidential Address to the Malacological Society, February, 1911.

THE subject of this address was chosen with a view of placing before the student of recent Mollusca one of the many important applications of the Mollusca found fossil as indexes to the age of the sedimentary rocks and consequent division of those rocks into zones. It is intended as a handy reference paper, includes an abridged table of the stratified rocks, and deals mainly with the Mesozoic beds. The paper is historical in arrangement, and the work of each successive man is easily ascertainable. In his abridged table Mr. Newton gives the chronological terms in general use and the equivalent British formations. As Dr. Marr indicated in his address to the Geological Society (1905), we require three groupings—(1) the formations more or less local, (2) the broad chronological divisions, and (3) the zones. That "Zones are belts of strata, each of which is characterized by an assemblage of organic remains of which one abundant and characteristic form is chosen as an index", may to a certain extent be conceded; but it must always be remembered that zones are not based on the fauna of a lithological division or formation; they are established by careful collecting of fossils stage by stage, and the zonal subdivisions ultimately adopted may or may not correspond with the lithological or purely stratigraphic divisions. As Dr. Rowe remarked in reference to Chalk zones, he "pins his faith to Zoology, and to Zoology alone", while at the same time he called attention to instances where the lithological and zoological boundaries happened to coincide. We are glad to see the term Bathonian restricted to the Great Oolite Series.

VIII.—Tables for the Determination of Minerals by means of their Physical Properties, Occurrences, and Associates. By Edward Henry Kraus, Ph.D., and Walter Fred Hunt, A.M. 8vo; pp. 254. New York and London: McGraw-Hill Book Company, 1911. Price $2 (8*s.* 6*d.*) net, post paid.

THIS set of tables is framed for the ready determination of 250 mineral species, on the basis of easily recognizable physical properties. Lustre and colour are the chief *fundamenta divisionis*; streak, hardness, and specific gravity being among the other characters tabulated. The tables are in two parts, according as the lustre is metallic or non-metallic; and colour is made an important basis, although for purposes of classification it is far from definite, and in the present work leads to much repetition.

The Introduction comprises a brief sketch of the physical properties of minerals, sufficient, possibly, to enable persons with a small amount of technical knowledge to handle the book with advantage. A glossary follows, and although this is delightfully brief and on the whole adequate, it might be improved by the excision of some terms and more attention to the connotation of others. The word 'waxy', for example, is given in the column describing lustre, and on referring to the glossary we learn that 'waxy' means "luster of wax". 'Interlaced,' we are told, means "intertwined, confused"; while 'refraction, double' is defined as "yielding two refracted rays", a definition that might well be objected to as logically inadequate.

Three kinds of type are used for the names of various species, and this feature is designed to indicate their comparative importance, and also to enable the book to be used by students of different grades. In this connexion it might be noted that the rarer felspar anorthite is given more prominence than labradorite. The authors have paid special attention to the associates and modes of occurrence of the minerals with which they deal, and valuable observations are to be found in the column relating to these features; but in the case of cassiterite there is no mention of chlorite as one of its important accompaniments.

The information is arranged as conveniently as possible, and opposite each name references are given to the well-known manuals of Kraus, Dana, and Moses & Parsons. The book is singularly free from typographical errors, though the spelling of 'sanidine' (p. 238) seems to have escaped revision. These tables evidence great care as regards detail, and being the result of wide experience, both in laboratory and field, should be of great value in the hands of students, teachers, and practical workers.

IX.—Brief Notices.

1. Canadian Rockies.—The *National Geographic Magazine* for June, 1911, is full of geological interest concerning the Canadian Rockies. Mr. C. D. Walcott gives a short sketch of the geology, refers to the Crustacean fauna of the Cambrian, figuring that remarkable Eurypterid *Sidneyia inexpectans*, and illustrating his notes with a beautiful series of photographs of Mounts Schaffer, Robson, Wapta, Huber, and President. Besides these we have a "Panoramic view from the west side of Burgess Pass, 3,280 feet above Field, British Columbia", which includes all the great peaks. This forms a folding plate 8 ft. 6 in. long, and is a fine effort of photography, reproduction, and printing by the Matthews-Northrup Works of Buffalo. It was taken by a Cirkut camera with a revolving bed, by a Bausch and Lomb Zeiss Protar, series vii, with an exposure of one-tenth of a second over each part of the film, and is well worth the attention of any photographer.

Other interesting matter in this number are papers on the glaciers of Alaska and Mount McKinley. We do not know any finer publication for scenery than this magazine, which is the official organ of the National Geographic Society of Washington, D.C.

2. Albania.—Of similar nature, though more scientific in character, is Franz Baron Nopcsa's paper on the stratigraphy and tectonics of the Scutari area in North Albania. The author deals mainly with the geology, which ranges from Palæocene to Trias, but illustrates his remarks on the tectonics with a series of fine photographic reproductions and a clear map. The paper appeared in the *Jahrbuch der k.k. Geol. Reichsanstalt*, Vienna, vol. lxi, 1911.

3. Tertiary of Japan.—Dr. Matajiro, Yokohama, has described the Tertiary fauna and flora brought up in borings 240–842 feet from Manoa in the Miike Coal-field. The forms belong to the Palæocene or Eocene of Europe, and include well-known forms like *Pholadomya margaritacea* (Sow.), *Aturia ziczac* (Sow.), and *Lamna* (cf.) *cuspidata*, Ag. There are also a crab, a Cycad, and a Pentacrinid. The paper, with three plates, appeared in Journal Coll. Sci. Tokyo, February, 1911.

4. Minerals in Dust.—Dr. W. N. Hartley (Proc. Roy. Soc., ser. A, vol. lxxxv, June, 1911) has "during the past twelve months" had occasion to ascertain the nature of the mineral constituents of an ordinary turbid atmosphere in Dublin. By means of a small portable quartz spectrograph several series of spark spectra were photographed with graduated exposures of 1, 5, 10, 20, 40, and 60 seconds, all on the same plate. The electrodes in the first series were cadmium, iron, nickel, and copper, a self-induction coil being interposed to eliminate the air spectrum and the short metallic lines. Thirteen minerals were recognized, and "as no atmosphere is free from dust, and that of cities is particularly dusty, these mineral constituents must be regarded as possible reagents in cases where there is evidence that very minute quantities of basic substances can initiate chemical

reactions and isodynamic changes, such as have generally been considered as spontaneous, and in all cases where a solution in contact with air is liable to be affected".

5. Palæontology at Shepherds Bush.—In the *Museums Journal* for May Dr. Bather describes and comments on "The Palæontology Exhibit at the White City, 1910 and 1911". Exhibits of modern British palæontology were organized by him in connexion with the Franco-British, Japan-British, and Coronation Exhibitions. The first illustrated methods of research, and the last two aimed at showing the scientific results obtained by those methods, especially such as could be obtained only by palæontology. By concrete illustration, the exhibit attempts to embody abstract philosophical ideas. Among the subjects thus elucidated are the restoration of extinct animals, the relations of extinct faunas and floras to those now living, variation in space compared with mutation in time, evolution of single lines of descent, recapitulation and rejuvenescence in individuals and in colonies. Among those to whose assistance Dr. Bather gratefully refers are Dr. C. W. Andrews, Rev. H. N. Hutchinson, Mr. G. C. Crick, Dr. Lewis Moysey, Mr. and Mrs. Clement Reid, Mr. G. E. Dibley, the Bristol Museum, Dr. A. Wilmore, Mr. R. G. Carruthers, Mr. C. P. Chatwin, Mr. T. H. Withers, Mr. H. L. Hawkins, Mr. W. K. Spencer, and Mr. W. D. Lang.

6. Sutherlandshire Gold.—We learn from *Nature* (July 13) that a new attempt is being made to work the alluvial goldfield in Helmsdale, in Eastern Sutherland. The existence of gold there has long been known, and some of the gold of the ancient ornaments found in North-Eastern Scotland may have come from that district as suggested by the Rev. J. M. Joass. The first modern attempt to work the field was during the years 1868 and 1869, when gold was obtained in the Kildonan and Suisgill Burns, two tributaries of the Ullie, the main stream of Helmsdale. Royalty was paid on about £3,000 of gold, but the amount obtained is said to have been considerably higher. According to Dr. Lauder Lindsay (quoted by Dr. J. Malcolm Maclaren) gold of the value of £15,000 was obtained from Sutherland in 1869. The largest nugget was found in the Kildonan Burn, and weighed 2 oz. 17 dwt. The richest alluvial deposits were in the Suisgill Burn, a higher tributary of the Ullie. This burn flows over mica-schists belonging to the Moine system, which have been invaded by granite dykes. The existence of gold in this granite was recorded by Bryce in 1870. The workings were stopped at the end of 1869 owing to damage done to the fishing and the farmers. A serious effort to reopen the field is now being made by the Duke of Sutherland. Gold is being obtained, but whether it occurs in paying quantities has still to be proved. Particulars of the geology of the district will be found in papers by Joass, Quart. Journ. Geol. Soc., xxv, p. 314, 1869; E. Greenly, Trans. Edin. Geol. Soc., vii, p. 100, 1895; and Maclaren, Trans. Inst. Mining Engineers, xxv, 1903.

7. South African Journal of Science.—In No. 6, vol. vii, 1911, Professor P. D. Hahn calls attention to the occurrence of a geyser in the Zambesi Valley, about 2 miles south of the river near Fulunka's Kraal, and 40 miles downstream from the confluence with the Gwai.

Information gathered on the spot by Mr. C. L. Carbutt indicates that the water, which is slightly below boiling-point, is emitted continuously. Mr. J. A. H. Armstrong contributes an account of certain rocks of Archæan age in Natal; they include gneiss, granite, and quartz-diorite.

8. Denudation and Corrosion.—Professor J. W. Gregory discusses the application of certain terms the use of which has become ambiguous (*Geograph. Journ.*, February, 1911). He suggests that *Denudation* be used for the wearing down of the land by any agency; *Erosion* for the lowering of the land by various subaërial agencies, including rivers and glaciers acting laterally; *Abrasion* for the destruction by sea; and *Corrosion* for the excavation by rivers and glaciers of their beds. He rightly dismisses *Corrasion* as a synonym of *Corrosion*.

9. The Glenboig Fireclay.—This fireclay, which is obtained from the Millstone Grit Series near Coatbridge, Lanarkshire, and is said to yield fire-bricks of unequalled quality, has been studied by Professor J. W. Gregory (Proc. Roy. Soc. Edin., vol. xxx, pt. iv, 1910). He finds that its clay-substance is an amorphous hydrous bisilicate of alumina, and may be regarded as the mineral halloysite; that the fireclay was a lagoon deposit, and that it contains zonal, lenticular, and rhombohedral crystals of sideroplesite, which formed in the water and on the floor of the lagoon.

10. Flint Implements of North Cornwall.—Mr. H. Dewey (Trans. Roy. Geol. Soc. Cornwall, vol. xiii, pt. vii, 1911) describes and figures some well-formed flint-flakes from the district of St. Clether and St. Tudy. The productive localities are situated on high land, often near ancient encampments, and their local abundance in St. Clether is suggestive of a manufactory of implements. It is considered unlikely that the material was obtained from any of the ancient or modern beaches, but that it was probably brought from the gravels of Haldon in Devonshire.

11. Arthur's Seat Volcano.—A description of this ancient volcano, by Dr. B. N. Peach, has been reprinted, with slight alterations, from the memoir on the Geology of the Neighbourhood of Edinburgh (noticed in Geol. Mag., March, 1911, p. 133), and has been issued by the Geological Survey, 1911, price 6*d.* It is accompanied by a coloured geological map on the scale of 6 inches to a mile, and by four text illustrations.

12. Miocene Mammals from Nebraska.—In the Annals of the Carnegie Museum (vol. vii, No. 2, 1911) Mr. O. A. Peterson describes (1) a mounted skeleton of *Stenomylus Hitchcocki*, a small aberrant camel, the first remains of which were discovered a few years ago. There have since been found in the Lower Harrison Beds more complete remains of this genus than of any other Miocene mammal. They were obtained by Dr. F. B. Loomis in a hill of closely packed and finely grained sand, about 60 feet thick, overlain by bedded sandstone, in the Niobrara Valley, Sioux County. The excavation is known as the Stenomylus quarry, and a plan is given showing the position of seventeen skeletons and other less complete remains in an area of about 75 by 20 feet. Mr. Peterson also describes (2) a new camel, *Oxydactylus longirostris*, from the same formation at Whistle

Creek, Sioux County, and (3) a mounted skeleton of *Diceratherium Cooki*, a form allied to Rhinoceros, from the Agate Spring Fossil quarries, also in Sioux County.

13. Underground Water Papers.—The United States Geological Survey have issued (as Water Supply Paper No. 258, 1911) a series of short papers relating to investigations of special underground water problems. Among the subjects we may mention that of Drainage by Wells, and the advantages, and possible disadvantages through pollution of water-supplies, are discussed; also the Freezing of Wells; and the Occurrence and Composition of Well-waters in Granites, concerning which it is stated that 87 per cent. of the wells drilled in granite in New England, of which records are available, were successful enough for ordinary domestic use. Most of these were from 50 to 100 feet deep. Another article on Magnetic Wells is of interest, as the phenomena are reported to "consist in the magnetization of needles, knife blades, nails, etc., immersed in the water, both at the source and at a distance, and in the deflection of the magnetic needle in its vicinity". It is well known that magnetism is exhibited by well-casings, and it is concluded "that the phenomena are induced by earth magnetism aided by the vibration of the drill or of the casing when it is sunk by percussion, which permits the readjustment of the polarized particles of the steel". Other articles deal with mineral springs, saline artesian waters, the protection of shallow wells in sandy deposits, etc. Water Supply Paper No. 257, 1911, consists of an essay on Well-drilling Methods, by Mr. Isaiah Bowman.

14. Geology of Melbourne.—A handy little book has been written on this subject by Mr. G. B. Pritchard (Melbourne, 1910, pp. 187, with 44 illustrations). The author's object is to encourage interest in the local geological features and to preserve records of those which are being gradually obliterated by the growth of the city. After an introduction, and short chapters on geological time and on fossils, the author conducts his readers on a series of rambles in and around Melbourne, and in the course of these he describes the local geology and also explains the method of construction of geological maps and sections.

15. Cambridge County Geographies.—Since our former notice of these publications, which are issued by the Cambridge University Press, price 1*s*. 6*d*. each (Geol. Mag., May, 1911, p. 232), we have received the volumes on Aberdeenshire by Mr. Alexander Mackie, on Huntingdonshire by the Rev. W. M. Noble, and on Worcestershire by Mr. Leonard J. Wills. The volumes are full of interesting matter and are well illustrated, Aberdeenshire naturally affording fine views of rock and mountain scenery as well as of granite works. It should be mentioned that relics of Pliocene, as well as Cretaceous and Jurassic formations, occur in the Glacial Drifts of that county. The Fens and their drainage receive attention in the volume on Huntingdonshire, and there is a view of a cornfield on the site of Whittlesey Mere. The volume on Worcestershire contains views of the Malvern scenery, but in this and in the volume on Huntingdonshire space is unnecessarily occupied by full tables of strata and general remarks on geology.

REPORTS AND PROCEEDINGS.

MINERALOGICAL SOCIETY.

June 13, 1911.—Professor W. J. Lewis, F.R.S., President, in the Chair.

G. S. Blake: On Zirkelite from Ceylon. The results of five analyses made on fragments grouped together according to their specific gravity, which ranged from 5·2 to 4·4, showed remarkable variation in the percentage composition, the densest containing about 20 per cent. thoria and little uranium, and the lightest 14 per cent. $U_3 O_8$ and little thorium; the precise formula is uncertain. A few crystals, some simple and some twinned, were met with; they apparently belong to the hexagonal system ($\mathfrak{cr}$ = 53° 22′), the observed forms being $\mathfrak{c}$ (0001), $\mathfrak{m}$ $(10\bar{1}0)$, $\mathfrak{r}$ $(10\bar{1}1)$, $\mathfrak{s}$ $(20\bar{2}1)$, $\mathfrak{d}$ $(10\bar{1}2)$, $\mathfrak{e}$ (2023), and $\mathfrak{r}$ the plane of twinning; they were opaque in mass, but translucent and isotropic in splinters.—Rev. Mark Fletcher: Note on some Crystals of Artificial Gypsum. The crystals, which were formed in the condensing plant of a distillery at Burton-on-Trent, were twinned about 101, and the forms 100, 110, 230, 111 were observed.—L. J. Spencer: The larger Diamonds of South Africa. Historical notes relative to the 'Excelsior', 'Jubilee', and 'Imperial' diamonds were given, together with a tabular statement of the weights of the rough and cut stones in carats and grams, and the percentage yield of the cut brilliants from the rough.—F. H. Butler: Brecciation in Mineral Veins. In vein-breccias due to fracture in situ (crush-breccias) replacement of country rock is a characteristic feature. Where the coarse fragments in a brecciated fissure-vein indicate erosion, removal of fine rock-debris may be inferred. Fragments that are angular and uneroded and completely isolated by encrusting material often indicate by shape and position their former existence as a single mass. The quiet removal of such fragments into a vein-cavity after reunion, and also the banding, with concomitant contortion of adjoining soft country rock, by their cement-substance, may be ascribed to the hydrostatic pressure and the solvent and mineralizing properties of the waters which furnished that substance. The coarse constituents of breccia may have been crushed in situ, or forced from fissure-walls by earth-movements, or detached therefrom by aqueous pressure and solution.—Arthur Russell: Prehnite from the Lizard District. Two distinct types of crystals, tabular and prismatic, were recently found by him on hornblende-schist at Parc Bean Cove, Mullion, Cornwall, the former showing the forms 001, 302, 061, and the latter 100, 001, 110, 061, and the rare form 301.

CORRESPONDENCE.

DREIKANTER.

SIR,—I am much indebted to Dr. Bather for pointing out, in your June issue, that when I wrote 'a dreikanter' I really meant 'a Dreikante'. As a matter of fact I meant precisely what I wrote, and still adhere to it, though I certainly should have written 'Zeuge' and 'Zeugen'. I wrote 'dreikanter' because it was the form used by your reviewer, and should certainly not have used 'Dreikante', as this form does not appear in the only German work [1] dealing with the subject that was available to me for reference. No doubt Dr. Bather has excellent grounds for the use of the form 'Dreikante', and so perhaps my authority was mistaken in his use of 'Dreikanter' in a German work presumably written for Germans.

His letter suggests the question of how far it is necessary to adhere to the original terminations for borrowed words when they fall into common use in English writings. It does not appear to be a great sin to drop them, while it would be intolerable to adhere to them in every case, and I am glad to find the form 'horsts' in the textbook reviewed.

After suggesting that we should be careful to avoid the use of foreign words through laziness or ignorance of our language and defining the qualities that a technical term should possess, Dr. Bather goes on to point out that wind-wearing is not implied by the word 'Dreikante', which, he says, means a tripyramidal or triquetral pebble, and that wind-worn stones of this shape are in a minority. 'Dreikante' implies three-edged and certainly might be rendered by 'triquetral'. Tripyramidal, however, is not such a happy suggestion. Dr. Evans, in a subsequent letter, speaks of the "tetrahedral or tripyramidal form", so we have two authorities each using the same term for something different. It may be suggested that, even if a tripyramid is a possible figure, it must have more than three edges, while it would be more correct to regard a tetrahedron as a tetrapyramid, since any of its four faces can be considered as the base of a pyramid formed of the other three. No doubt the idea Dr. Bather desired to convey by 'tripyramidal' was a closed form bounded by three curved faces, any one of which may be regarded as the base of a pyramid whose apex is the summit of the curved edge in which the two other faces meet. Such a figure is probably more correctly described as a trigonal bipyramid with curved faces.

The term 'Dreikanter', though it does not literally imply wind-action, probably suggests the most typical form of a wind-worn pebble, and has gained wide acceptance in this particular sense, whether the form is only in the process of achievement or whether it has been modified by the formation of other facets.

I have not yet seen dreikanters in the Sudan, nor had the opportunity of studying their formation elsewhere. The object of my former letter was to point out that the phrase suggested as an alternative by your reviewer did not mean the same thing, and, though Dr. Bather admits the truth of this, I regret that his letter gives the impression that he attaches more importance to the correctness of the terminations than to the sense of the word. Doubtless this is not the impression he desired to convey.

G. W. Grabham.

Madeira.
July 10, 1911.

[1] Walther, *Denudation in der Wüste.*

OBITUARY.

ALFRED ELIS TÖRNEBOHM, Ph.D.

Born October 16, 1838. Died April 21, 1911.

We regret to record the death, at the age of 72, of Dr. A. E. Törnebohm, who was Professor of Mineralogy at the Technical College at Stockholm from 1878 to 1897, and Director of the Geological Survey of Sweden from 1897 to 1906. He was elected a Foreign Correspondent of the Geological Society of London in 1910. He was author of papers on the Silurian and older rocks of Sweden, and on the Glacial phenomena of Sweden, Norway, and North Germany. He regarded the Swedish rock-basins as due to disturbances during the Glacial Period. Dr. Törnebohm gave special attention to the iron-ores of Sweden, and published nine maps of the principal districts where they occur (1879–82). He also published a series of microscopical rock studies, with descriptions of the rhomb-porphyry and many other rocks, his later work, apart from his Geological Survey publications, being mainly petrographical. He was author of *Grunddragen af Sveriges geologi*, 1884, of which a third edition was published in 1901; and of *Die Petrographie des Portland Cements*, 1897.

MISCELLANEOUS.

A Palæontologist for the Geological Survey and Department of Mines, New Zealand.

It is now thirty-six years ago since Dr. (afterwards) Sir James Hector came to England on a visit from New Zealand, where he was at that time Director of the Geological Survey. He brought over a number of fossils to the British Museum with the intention of having them described, a task which the late Mr. Robert Etheridge, F.R.S., undertook, but, alas! did not accomplish owing to the pressure of Survey work here.

I remember describing and figuring a new fossil crab, *Harpactocarcinus tumidus*, from the passage-beds, Ototara Series, Woodpecker Bay, South Island, New Zealand, to which Dr. Hector kindly added a Note on the Geology with a section from the Alps to Brighton, New Zealand, and a table of formations (see Quart. Journ. Geol. Soc. London, vol. xxxii, pp. 51–6, pl. vii, 1876). I was since kindly invited by the late Captain F. W. Hutton to contribute some further notes upon New Zealand Crustacea, but regret to say they still remain unwritten.

It is with extreme pleasure that I learn the Geological Survey of New Zealand have at length decided to appoint a palæontologist. This seems to be the outcome of representations made by the Australasian Association for the Advancement of Science, recommended also by Mr. A. Hamilton, Director of the Dominion Museum; and Mr. P. G. Morgan, the new Director of the Geological Survey (who has been appointed in succession to Dr. Bell), has no doubt added weight to these recommendations.

The collections accumulated, under the regime of Dr. Hector, probably exceed a hundred thousand specimens, of which very few have been described, but happily they all bear locality labels.

It is gratifying to learn that the post of palæontologist to the Geological Survey of New Zealand has been offered to and accepted by Mr. James Allen Thomson, M.A. (N.Z.), B.A. (Oxon.), B.Sc. (N.Z.), F.G.S. (lately of Kalgoorlie, Western Australia), who has had the advantage of an admirable University training in Geology and Palæontology both in New Zealand and in Oxford, and will come to the arduous task of working up the old and new collections with the courage of one who is determined to win his way to the front, feeling assured of the earnest support and good wishes of all his fellow-geologists here as well as in New Zealand.

Too great praise cannot be accorded to the Colonial Government in consenting to the appointment of a palæontologist, which in all mining countries is looked upon rather as an ornamental office. Many years since, the Minister of Mines asked the question in Sydney: "Mr. Etheridge, *palæontologist*: what's that?" The Director replied: "A gentleman who can break rocks and understands fossils." "Oh!" said the Minister; "a labourer at two dollars a day could do that." They don't say that of Robert Etheridge of the Australian Museum now; he is one of the burning and shining lights of the Survey and the Museum, and in January last was "awarded the 'Mueller Memorial Medal' for his great services to the cause of science, especially in connexion with palæontology".[1]

No doubt in the progress of time the Australian Association, or some other learned body, will be able similarly to commend the palæontologist of the New Zealand Survey for work accomplished. We feel sure that the Dominion may obtain much help if the Survey make a friendly appeal to specialists in palæontology in this country to assist by the description of certain collections, subject of course to the specimens being returned to Wellington. (There are lots of duplicates.) Such groups as the Vertebrates, the Cephalopoda, the Graptolites, and the Mesozoic plants may serve as illustrations where assistance will certainly be needed.

A library of palæontological works will also have to be provided, for which help would doubtless be forthcoming in many quarters if the Survey make a suitable appeal.

H. W.

Geological Survey of India.

Applications are invited for the post of an Assistant Superintendent in the above Department. Candidates should have a first-class all-round knowledge of geology and a good general education; age not to exceed 25 years. The candidate selected will be required to leave for India towards the end of the year. Further particulars may be obtained from the Secretary, Revenue Department, India Office, London, S.W.

[1] See Geol. Mag., May, 1911, p. 240.

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ASSISTED BY

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OCTOBER, 1911.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VIII.

No. X.—OCTOBER, 1911.

ORIGINAL ARTICLES.

I.—Some Notes on the Geology of the Bermuda Islands.

By R. Ashington Bullen, B.A. (Lond.), F.L.S., F.G.S.

(PLATES XXI–III.)

(*Concluded from the September Number, p.* 395.)

(4) *Recent Æolian Sands.*—On the south shore the sand has made or is making some encroachments on the land, in others on the sea. The 'live' sand-dunes are principally to be found at Tuckerstown, but there are some movements at Elbow (or Middleton) Bay and at Warwick Long Bay. The shell-sand is mostly made up of the broken shells of various marine species, some few being entire, with which are mingled the broken tubes of serpulæ, fragments of nullipores and corallines, and the red shells of a *Vermetus*, viz. *Teganodus* (*Siliquaria*) *ruber*, Schum. This latter is so plentiful as to give a distinctly red appearance to the sand of some beaches.

The coarsest sand on the islands (according to Mr. Richard Kempe, who has lived in the islands since 1848) occurs at Astwood's Bay, in Warwick parish. In other bays the sand varies in size of grain, and a great deal of the finer material is no doubt derived from the degradation of the former coast and cliffs. The present cliffs on the south shore are from 30 to 50 feet high. The former shore extended seaward to a distance of a little over 300 to rather over 700 yards from the present shore-line. The erosion of this coast must have commenced before the deposition of the Devonshire formation, which Verrill places in the Champlain or Post-Glacial Period.[1] The Devonshire Beds at Hungry Bay abut on the eroded Walsingham rocks.

The blown sands act as protectors of the present cliffs, as at Warwick Long Bay, where a chain of sand-dunes, 'anchored' by such plants as sea-lavender (*Tournefortia gnaphaloides*, R. B.), indigo-berry (*Randia aculeata*, L.), and crab-grass (*Stenotaphrum Americanum*, Schr.), are a distinct advanced guard, and, by keeping together the sand, prevent the further inroads of the sea (see Plate XIX). At the same time there are occasional extensive falls of the higher cliffs, as at Kempe's Bay (Pl. XX, Fig. 1), where at the time of my visit some 100 tons or so of the loosely compacted Paget Beds had fallen to the present beach. It is such falls that account for the land shells (*Pœcilozonites Bermudensis*, var. *zonatus*, Verrill) which occur on the marine beach (Text-fig. 4).

[1] Verrill, "The Bermuda Islands: Geology": Trans. Conn. Acad. Arts Sci., vol. xii, p. 75.

Sir Wyville Thomson[1] described an encroachment of sand at Elbow Bay, to which he applied the name of sand 'glacier' (July, 1873). He describes the steady progress of this destructive invasion, covering cultivated land, overwhelming a house, and advancing through a wood of 'cedars' (*Juniperus Bermudiana*, L.). Since 1873, however, this sand 'glacier' has ceased to advance landward. Various plants, such as the grape-mangrove (*Coccolaba uvifera*, L.), the seaside vine (*Ipomæa pes-capræ*, Sweet), the bay-bean vine (*Canavalia obtusifolia*, D. C.), burr-grass (*Cenchrus tribuloides*, L.), and crab-grass (*Stenotaphrum Americanum*, Schr. = *S. glabrum* of Lefroy[2]), have 'anchored' the sand, so that it is no longer a menace. Sir Wyville Thomson writes of 'coral' sand in this account and elsewhere: as a matter of fact, there is no such thing as coral-sand in Bermuda; the present beaches are not indebted to coral for their materials, but to various marine molluscs, corallines, algæ, serpulæ, Foraminifera, the tests of echini, Crustacea, etc.; coral is generally conspicuously absent.

The material that constitutes the present shore sand is washed in from comparatively shallow depths, whereas coral lives at depths of "from 5 to 6 fathoms on the inner edge of the flats to the outer limits, the beginning of the broken ground, the corals extending to 8 or 10 fathoms on the southern faces of the flats".[3] He also says: "The Bermudian reef corals are, like the Bahama reefs, submerged, rarely come to the surface, and have not supplied any considerable part of the material which has gone to build up an extent of land either in the Bahamas or Bermudas." This, any field geologist would corroborate.

The marine mollusca that contribute to the present shell-sand of the recent beach are represented by the following genera: *Arca*, *Barbatia*, *Bulla*, *Callista*, *Cardium*, *Cerithium*, *Columbella*, *Conus*, *Cylichna*, *Cyphosoma*, *Cypræa*, *Dentalium*, *Diplodonta*, *Eulima*, *Fissurella*, *Glycimeris*, *Melampus*, *Murex*, *Nassa*, *Nerita*, *Olivella*, *Patella*, *Pecten*, *Rissoa*, *Spirula*, *Spondylus*, *Trivia*, *Vermetus*. There are probably many others, but these are in my own cabinet.[4]

It would extend these notes unduly if I were to describe the swamps, which, though not very extensive, are of great depth, and may go back to very early times, but as they have not been explored downwards there is but little known with sufficient exactness for any lengthy geological report. Suffice it to say that Governor Lefroy found the depth of the peat in Pembroke marsh in 1872 to be 42 feet.

IV. The Serpuline 'Atolls' or 'Boilers'.

The term here used refers to the round, or horseshoe, or S-shaped, or compound-shaped reef edges which occur on the south shore (Pl. XX, Fig. 2). "They are, perhaps, the most interesting structures in the Bermudas. They . . . constitute miniature atolls and barrier and fringing reefs, apparently formed by the growth of serpulæ. While serpulæ undoubtedly cover a great part of the

[1] *Voyage of the "Challenger"*, vol. i, p. 310, figs. 74–6.
[2] Lefroy, *Botany of Bermuda*, 1874.
[3] Agassiz, *A Visit to the Bermudas in 1894*, pp. 237, 243.
[4] Through the kindness of Miss Aimée Kempe, of Warwick parish.

surface of the structures, yet calcareous algæ, corallines, barnacles, mussels, and other invertebrates are found to be fully as abundant as the serpulæ, which, in many cases, play only a secondary part in the organic covering . . . Before my visit to the Bermudas, I accepted the explanation given by older writers of the mode of formation of the atolls, as due to the accelerated growth of serpulæ on the outer rim. I was therefore greatly surprised on hammering at some of these structures to find that the vertical walls were not built up, as is generally believed, of serpuline limestone, but were composed of æolian rock, and to discover that in many cases the elevated rim was protected by the hard ringing crust so characteristic of limestone exposed to the action of the sea, and, further, to find that the coating of serpulæ, algæ, corallines, and nullipores was quite superficial." Agassiz [1] gives good reason for believing that these miniature reefs are caused by the gouging action of the surf on æolian rock, submerged at high tide, but at other times elevated a foot or so above the water, on which the incessant play of the waves has a degrading effect. The growth of serpulæ, etc., protects the outer rim, and these interesting structures are the result.

The serpulæ are curiously more abundant on the south 'reefs' than on the north flats. There this phenomenon is not so well developed; the surface of the northern ledges are mainly protected by a small species of barnacle, clusters of *Mytilus*, encrusting nullipores, and a few small species of algæ.[2]

V. The Foraminifera.

I am indebted to Mr. Richard Holland for the following report on the Foraminifera which I have submitted to him :—

"Six packets of various kinds of materials were sent to me for examination, namely—

I. Coarse recent sand from Mermaid's Hole.
II. Fine recent sand from Long Bay.
III. Very fine fossil sand from near the Park, St. George's.
IV. Fine sand, probably from Shelly Bay.
V. } Fine sandy material collected from the insides of various land shells
VI. } from the Paget formation.

"*Specimen I.* This might fairly be described as a shelly gravel. It contains no fine material, and is, in fact, too coarse for the occurrence of Foraminiferal debris or even entire Foraminiferal shells. It consists largely of molluscan debris with coarse sponge spicules and other organic remains.

"*Specimen II* has a general resemblance to Specimen I, but it is much finer, and includes a great quantity of Foraminiferal debris, rolled and worn *Orbiculinæ* and *Orbitolites*, and numerous complete smaller shells.

"Both Specimen I and Specimen II are perfectly clean sands, with not the slightest admixture of mud, calcareous or other.

"*Specimen III* is a fine sand with a slight admixture of calcareous

[1] Agassiz, *A Visit to the Bermudas in 1894*, pp. 264–7, figs. 1–7. Also Nelson, op. cit., p. 116, figs. 11–13.

[2] Agassiz, op. cit., p. 264.

mud. It is full of Foraminifera, many of them in a very good state of preservation. The sand is described as fossil, but it is probably of late Post-Tertiary age. The shells are essentially similar to those from the recent beaches, and there is no trace of mineral infiltration.

"*Specimen IV* is said (but with some hesitation) to come from Shelly Bay, and I understand that it is thought to come from the recent beach. I doubt this. It is certainly different in character from Specimens I and II, and I am inclined to think that it is *washed* material from a deposit similar, but rather richer, to that from which Specimen III was taken. It is the best material of the six specimens for Foraminifera, and it is particularly rich in good specimens of *Orbiculinæ*. I should think it probable that similar material was in Carpenter's possession when he wrote the chapter on *Orbiculina* in the *Introduction to the Foraminifera*.[1]

"*Specimen V* and *Specimen VI* are somewhat similar in character to Specimen III, but considerably more muddy and with no perfect shells. There are abundant traces of Foraminifera, but all much decayed. The shell debris shows no trace of mineral infiltration, and the mud is apparently entirely calcareous.

"The material taken as a whole seems to me to represent a continuous series, that is to say, while Specimens I and II are clearly recent, the doubtful Specimen IV and the fossil Specimens III, V, and VI are of very late geological age and present no fundamental differences, beyond decay from weathering, from the recent material. The only noticeable distinction is that Specimen IV, which, however, I think has in all probability been washed, is richer in *Orbiculinæ* of large size than any of the other specimens.

"So far as the Foraminifera are concerned the material is remarkable for its great richness in fine specimens of *Orbiculina adunca* (Fichtel and Moll), in every stage of development and in wide variety of form. But Bermuda has long been known as an exceptionally good locality for that species, both in the recent and in the sub-fossil condition. Every variety of *O. adunca* figured either by Carpenter in his *Introduction to the Foraminifera*, or by Brady in the *Challenger* Report, is represented in this material, and the specimens are exceedingly abundant.

"As is usual in deposits very rich in examples of a particular species, this material does not furnish a wide variety of other genera and species. There are numerous specimens of Milioline forms, including *Biloculina ringens* (Lamarck), *Miliolina seminulum* (Linné), *M. pulchella* (d'Orbigny), *M. bicornis* (Walker & Jacob), and *M. reticulata* (d'Orb.). Fragments also of *Vertebralina* and *Articulina* have been met with. There are a few fragments of *Peneroplis*, numerous fragments of *Orbitolites*, and some young specimens of the genus in a good state of preservation. There are some good specimens of *Alveolina melo* (Fichtel & Moll), both recent and fossil; and some well-preserved examples of *Nonionina depressula* (Walker & Jacob) and *N. Boneana*, d'Orb. A very few small and obscure *Dentalinæ* have also been met with.

[1] Formerly in Dr. Henry Woodward's cabinet.

"The arenaceous forms are not well preserved. There is a considerable amount of debris, and some fairly good specimens of *Clavulina angularis*, d'Orb., have been found."

VI. Some Recent Evidence of Submergence.

(1) *Phosphorite Rock from Manhattan Shoal* (Pl. XXIII, Fig. 2).—In the Museum at Hamilton there is a large block of red rock from the Manhattan Shoal, probably a core from a hole made in blasting the rock for deepening the navigation channel in 1847. It came from a depth of 18 feet. If this were below O.D. it would be from 4 feet in the rock, which is probably the depth, more or less, of this interesting formation. Mr. L. L. Mowbray has kindly permitted me to sectionize the material and to have a petrological report inserted in this paper.

Mr. Russell F. Gwinnell, B.Sc., F.G.S., A.R.C.S., reports as follows:—

"This is a hard rock which does not effervesce on treatment with cold concentrated H Cl. Generally brown-red in colour, it appears in the hand-specimens to consist mainly of small spherical and ellipsoidal bodies together with a few subangular fragments, bound together by a cement which does not fill up the interspaces between the round bodies. There is no apparent striking difference in colour or hardness between any of the constituents of the rock (Pl. XXIII, Fig. 2).

"Under the microscope the round bodies are seen to be of various sizes, from a diameter of about 1·5 mm. down to perhaps 0·1 mm.; a great many are approximately 0·4 or 0·5 mm. in diameter. They show a certain amount of concentric zoning of colour, often with a lighter interior and darker border; otherwise there is no well-defined structure (as is frequently seen in oolitic and pisolitic grains), but the whole body contains numerous irregular fragments scattered promiscuously throughout. This structure is strongly suggestive of coprolites. The rounded bodies are non-pleochroic and isotropic. All the characters, so far, suggest the material as being phosphorite, the amorphous variety of calcium phosphate ('apatite' when crystalline) having been originally produced as coprolites, that is, the excrement of such animals as fishes or birds. For this reason, chemical tests for phosphorus were kindly made for me by Mr. T. Eastwood, A.R.C.S., and the presence of this element was clearly indicated. The rock also contains a few small subangular pieces of quartz and calcite.

"Encrusting the rounded bodies (which will now be spoken of as 'guano' or coprolites) is a thin layer of a transparent material, nearly colourless in thin section. This material also occurs apparently inside a coprolite, but this appearance may be due to the invagination of the surface of the coprolite. In polarized light this encrusting material is seen to be anisotropic, formed of fibres arranged normally to the surface which is encrusted. The birefringence is very low, but the refraction decidedly high. The fibres give straight extinction between crossed nicols, and a determination of the optical sign proves the material to be negative. These optical characters, together with the mode of occurrence, leave no room for doubt that this encrusting mineral is staffelite, a fibrous encrusting crystalline variety of calcium phosphate. A comparison of this rock with other examples of phosphorite with encrusting staffelite shows a high degree of resemblance.

"Coprolitic phosphorite, being amorphous and variable in composition, has no definite specific gravity, but as crystalline apatite reaches up to 3·2, we may consider phosphorite to be perhaps 10 per cent. lower, or about 2·9. Taking the specific gravity of the rock in mass with a Walker's steelyard, a value of about 2·6 was obtained, but this was obviously much too low, owing to air imprisoned in the interstices. A piece of the rock was therefore broken up and the crushed fragments placed in a heavy liquid. By this method, using Klein's solution (cadmium borotungstate in water), the specific gravity was determined with some accuracy to be 2·91.

"The rock No. 1 may therefore be described as phosphoritic rock with staffelite. Its origin may perhaps be accounted for by the accumulation of the excrement of fishes or more probably of birds." [1]

In a second communication Mr. Gwinnell says that a confirmatory test for phosphorus in the rock had been performed and shows the abundant presence of phosphorus. He has thus proved the presence of phosphorus by both dry and wet chemical methods, as well as recognizing the phosphorus-bearing mineral by specific gravity and by a number of optical properties.

(2) *The Crystal Cave, near Bailey Bay.*—This cave has been opened to the public within the last two years. As it is lighted by electricity the dazzling beauty of the stalactites has not been spoiled by smoke. It was discovered by the persistent selling by boys for some time of stalactites of great purity and beauty but of unknown provenance. The source of their supply was at last found out. They used to enter down a natural sloping passage (now artificially closed) which had also been the entrance for the numerous birds which left their bones for the present race of naturalists to find and describe. Mr. L. L. Mowbray is to be congratulated on the discovery of so many avian skeletons and also of their feathers preserved in the stalactite. The determination of these remains is being steadily pursued, and geological science will soon be enriched by their accurate description and diagnosis.

The salt-water lake in the cave is called the 'Cahow' Lake, in honour of the bird, now extinct, which frequented the islands 300 years ago in great numbers, but was ruthlessly exterminated about 250 years since, being hunted in the night.[2]

[1] The second alternative seems to me to be the most feasible. It is difficult to conceive such a hard rock being formed under salt water from such materials. Such crystallization would more likely take place on land elevated above the sea-level, where crystallization could go on at the base of guano beds. Solid rock is not forming under the sea at the present day. Wherever the sea bottom is dredged the material is unconsolidated at all depths from 1 to 10 feet, and is mostly an impalpable mud containing numerous shells quite loose in the dredged material. (Verrill, op. cit., pp. 138 seqq.)

[2] Verrill, op. cit., p. 258, quoting a letter dated 1614, written by the Rev. Lewis Hughes. "Here is also plenty of sea-foules, at one time of the yeare, as about the middle of October, birds which we call Cahouse and

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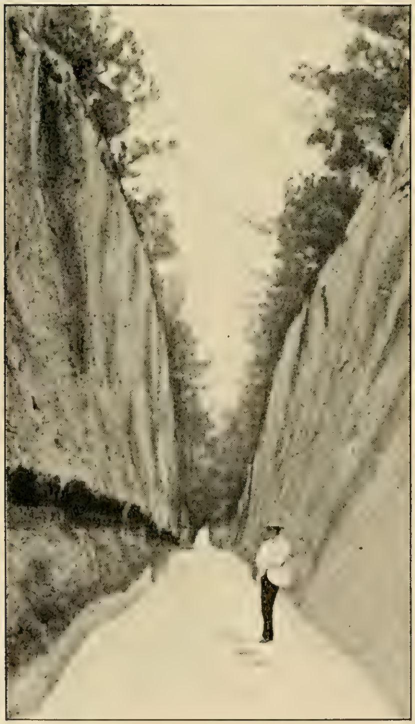

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1. Deep cut, 'Khyber Pass,' Warwick Parish, Bermuda.
2. Pinnacles, æolian rock, St. George's, Bermuda.
3. Pinnacle in process of formation, Bailey Bay, Bermuda.

The Crystal Cave is now entered by stairs to about a depth of 90 feet, and then progress is made on floating pontoons. The water in this cave is some 12 to 20 feet deep; the lower parts are completely submerged at all times of the tide, for the water inside rises and falls with the tide outside, the average fall and rise of which is about 4 ft. 7 in.

There are three very large stalagmites as well as several smaller ones, but the larger ones challenge attention by their great size. The gangway passes quite close to the largest, which as nearly as we could judge is some 7 feet in diameter at the base, about half that at the summit, and at least 10 feet high. It is much larger than the 'Milne' stalagmite, now in the Edinburgh Museum, which was sawn off in 1819 by Admiral Sir David Milne from the cave near Tom Moore's Calabash-tree. This was 11 ft. 3 in. high, 25 inches in diameter, and weighed $3\frac{1}{2}$ tons.[1] (The diameter at the apex was of course less.) The stalagmite at the Crystal Cave weighs at least 12 tons.

These huge masses of carbonate of lime were formed when the cave stood at a much higher level, since it would be quite impossible for them to form in their present position under sea-water. Moreover, there must have been a much greater rainfall than at present to have dissolved and scoured out this magnificent cave, and this points to a land surface at a higher level for the cooling and precipitation of aqueous vapour.

VII. The Grey Rock from the Deep Cut at Warwick (*vulgo* 'Khyber Pass'). (Pl. XXI, Fig. 1.)

This rock is the most puzzling of all the rocks from Bermuda. In the Museum at Hamilton is a small mass of hardened rock from

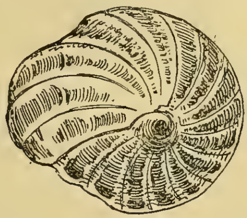


Fig. 5. *Peneroplis pertusus*, grey rock, 'Khyber Pass,' Warwick East, Bermuda. × 40 nat. size.

a depth of 32 feet in the Paget formation, found in blasting the road. This road has been deepened from time to time so as to make the gradient more easy for carts and horses.

Pimlicoes come in. The Cahouse continue til the beginning of June in great abundance, they are bigger bodied than a Pigeon and of a very good and firm flesh. They are taken with ease if one do but sit downe in a darke night and make a noise, there will more come to him than he will be able to kill: some have told me that they have taken twelve or fourteen dozen in an hower." (The names are onomatopœic, from the cries of the birds. The pimlico has been identified as the 'dusky' or Audubon's shearwater; *vide antea.*)

[1] Verrill, "The Bermuda Islands: Geology": Trans. Conn. Acad. Arts Sci., vol. xii, p. 85, note.

In one small piece which I also owe to Mr. L. L. Mowbray is a cast of *Peneroplis pertusus* (Fig. 5 text). The specimen from which the cast comes must have been quite unworn and perfect. The position is some 75 feet above O.D., and at a distance of about 580 yards from the present shore on the south side.

I append the petrological report of Mr. Russell F. Gwinnell :—

"This rock is seen in thin section to be composed of fragments of organisms (preserved in calcium carbonate) which are embedded in a dense grey-brown cement. The organic fragments reach up to about 0·8 mm. in greatest diameter. They are very varied in form, and it is impossible to identify many of them (Pl. XXIII, Fig. 1). Some may very likely be Bryozoa, others coral. A few pieces are definitely recognized as the calcareous alga *Lithothamnion*, which is a very well-known form on coral reefs.

"The dense cementing material is difficult to identify. It may be a calcareous mud, formed of comminuted organic fragments and possibly compacted by a certain amount of secondary recrystallization. If so, this recrystallization has not gone far. The comminution may be due to purely mechanical causes or the material may have passed through the body of some animal, thus being coprolitic. A minute fragment, which was not used in making the thin section, was therefore tested for phosphorus: owing to the small size of the fragment, the test was not decisive,. but it is probable that this element was present. The curious colour of this cementing material in thin section and its apparently fragmental character would suggest a coprolitic origin.

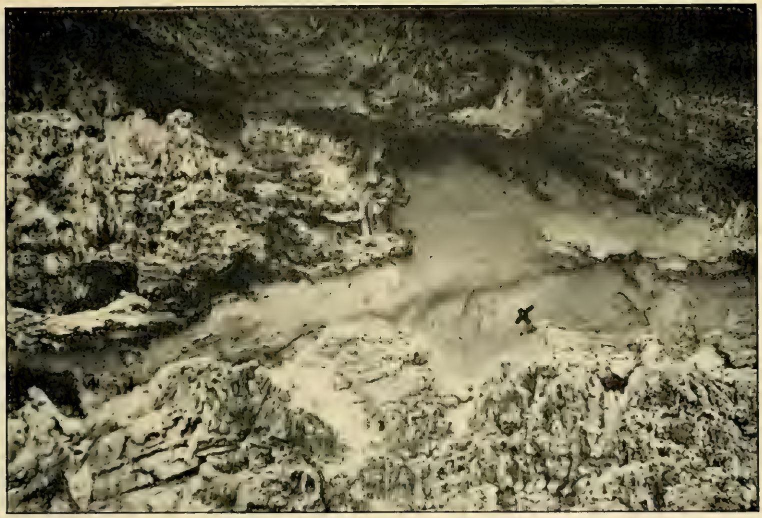
"Thus rock No. 2 is a clastic rock, made up of organic fragments (of which some are definitely recognized as coral-reef forms, and others may well be so), cemented together by a dense material. This cement probably consists largely of comminuted organic fragments, which have possibly been phosphatized (as well as comminuted) by coprolitic means."

The puzzle is how the perfect Foraminifer (Text-fig. 5) could have reached a spot so far from its native element and become embedded in what has become hard dense coprolitic rock.

The explanation perhaps is that the rock was formed in a spot to which sea birds resorted, and their deposit was calcified in later times gradually and slowly, the *Peneroplis* having been blown thither by the wind uninjured, since it could not have been ingested by any sea bird and remained in so perfect a condition as its cast shows it to have been. It is to be hoped that more of this type of rock may be discovered near the spot, for the rock at the Museum is evidently only a small fragment of a much larger mass.

The only other alternative is so improbable that it is only needful to mention it, namely, that the specimen is from a deep-sea mud, of which there are soundings from depths of 1,375 to 2,650[1] fathoms.

[1] Wyville Thomson (*Atlantic*, vol. i, p. 99) gives the depths at which such grey mud and ooze occur near the Bermudas: Station xxxi, S. 2,475 fathoms; Station xxxii, S. 2,250 f.; Station xxxiv, N. 1,375 f.; Station xxxvii, E. 2,650 f.; Station lv, N. 2,500 f.; Station lviii, E. 1,500 f. The respective



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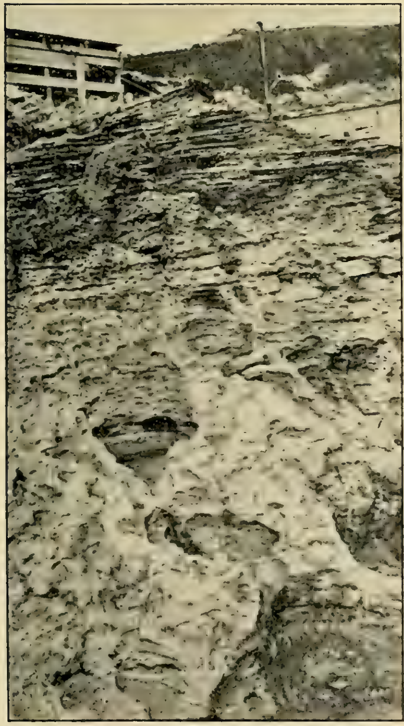

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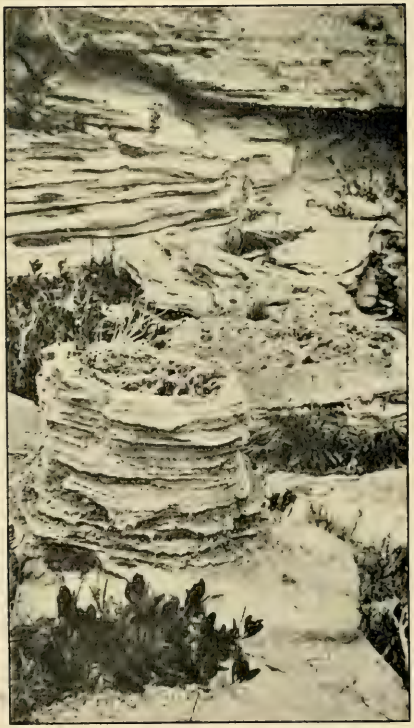

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1. Pot-holes in process of formation, St. David's Head, Bermuda.
2. Pseudo-palmetto stump, cliff, Hungry Bay, Bermuda.
3. Reticulated and honeycombed hard limestone, Bermuda.

This would account for the perfection of the Foraminifer, but not for the coprolitic nature of the principal material.

VIII. Some instructive Photographs.

(1) *The Carving Out of Pinnacles.*—One of the photographs which I took at 7 p.m. shows a pinnacle on the north shore near St. George's, probably in the Walsingham formation (Pl. XXI, Fig. 2). The hardening of the rock near the sea, by whatever agency it is effected, results in some remarkable structures. If the whole mass were to become indurated there would be merely a dense rock of more or less monotonous outline. But inasmuch as the shell-sand becomes more compacted into hard rock in some parts than in others, in consequence of percolation acting irregularly, there are often pockets of loose sand contained in harder rock. When the loose sand is washed or blown out, pinnacles are sometimes the result.

This is clearly seen in the second photograph (Pl. XXI, Fig. 3). The soft sand is being carved and etched out by the very agency that originally deposited it. The unconsolidated sand is seen as being cut out gradually by æolian action, and a pinnacle is in process of formation, like the finished pinnacle of the former photograph. The shell-sand here contains numerous land shells of the species *Pœcilozonites Bermudensis*, var. *zonatus*, Verrill, which can be seen in relief on the wind-cut surface. This natural arch is at Bailey Bay, also on the north shore. It belongs to the Paget Series (Pl. XXI, Fig. 3).

(2) *The Formation of 'Pot-holes'.*—The view is at St. David's Head, near the lifeboat station. In the upper part of the section is seen the wind-blown nature of the shell-sand formation (Walsingham Series). Lower down the action of the rain and spray has produced a honeycombed or reticulated appearance in the rock surface, which is pitted with small holes. On the face of the opposite rock is seen the process of formation of a 'pot-hole', by the revolving action of three stones which are swirled round and round by the impact of the waves during strong winds (Pl. XXII, Fig. 1).

(3) *'Pseudo-palmetto Stumps.'*—'Pot-holes' are considered by some to be the same as the 'pseudo-palmetto stumps'. The indurated sides of 'pot-holes' are supposed to become hard cylinders, and when weathered out to look like the stumps of trees. This may be so if it can be proved that they do weather out in this fashion, but it is quite as likely that they are drainage holes in the older Walsingham rocks; the calcitic material in solution, being deposited on the vertical sides of these watercourses, would cause the formation of these tubular pseudo-fossils from which the less dense external shell-sand has been denuded.

There are places where 'pot-holes' occur so thickly that they could not be the fossil remains of a grove of palmettos.[1] It is not their habit to grow so thickly together, and they prefer a peaty boggy soil, of which there is not the slightest indication in the structure of

distances from Bermuda of the first five are 53, 26, 18, 43, and 66 miles respectively. The distances are prohibitive of the second explanation, even if the enormous depths did not forbid.

[1] Agassiz, *A Visit to the Bermudas in 1894*, p. 269, pl. xxix.

the surrounding rock. Wyville Thomson[1] considers these pseudo-palmetto stems to have been formed on the floor of caves by the dropping of water charged with calcic material in solution. But these pseudo-palmetto 'fossils' are mostly hollow, while stalagmites are not. The pseudo-palmetto fossil figured is from the Walsingham rock on the east side of Hungry Bay (Pl. XXII, Fig. 2).

In conclusion, I would thank those in Bermuda whose names have been mentioned in the course of this paper, also Dr. Henry Woodward for editorial advice, Mr. Bullen Newton for access to Major Peile's collection at the British Museum (Nat. Hist.), Mr. Holland for examining and reporting on the Foraminifera, and Miss G. M. Woodward for preparing the illustrations.

EXPLANATION OF PLATES.

Plate XXI.

Fig. 1. Deep cut (' Khyber Pass '), Warwick parish, from a view published in Bermuda.
,, 2. Pinnacle in æolian rock, St. George's, north shore.
,, 3. Pinnacle in process of formation by æolian agency, Bailey Bay, north shore.

Plate XXII.

,, 1. ' Pot-holes ' in process of formation, St. David's Head.
,, 2. ' Pseudo-palmetto stump,' cliff east side of Hungry Bay.
,, 3. Reticulated, honeycombed, hard limestone, showing effect of sea spray, rain, and air on exposed rock. In the centre of the rock is a pocket of soft shell-sandstone. Both the hard and the soft rock contain innumerable land shells of *P. Bermudensis*, var. *zonatus*, Verrill, and belong to the same series of Paget rocks. At ' x ' a fine *Livona pica* was dug out by Mr. E. Morton Ingraham, of New Britain, Conn., U.S.A.

Plate XXIII.

,, 1. Grey rock from the ' Khyber Pass ', Warwick, Bermuda. × 8·5.
,, 2. Phosphorite with Staffelite (Guano rock), Manhattan Shoal, near Paget Island, St. George's, Bermuda. × 10.

II.—On the Tuberculation of the Holectypoida.

By Herbert L. Hawkins, M.Sc., F.G.S., Lecturer in Geology, University College, Reading.

I. INTRODUCTION.

ONE of the most obvious contrasts between the Regular and Irregular Echinoids is in the character of their radioles, and of the tubercles on which the radioles are supported. Among the Regulares the size of the radioles is usually in inverse proportion to the number which rest on an individual plate of the test; and, to some extent, the same generalization applies to the Irregulares. There is, however, a differentiation of the radioles among the more typical Irregular groups, which results in a corresponding irregularity in size and disposition of the tubercles. Generally speaking, the radioles of the Regulars are stout and few, while those of the Irregulars are slender and numerous. While, in an *Echinus*, the largest and strongest of the radioles are ambital, or even superior

[1] *Atlantic*, vol. i, p. 330.

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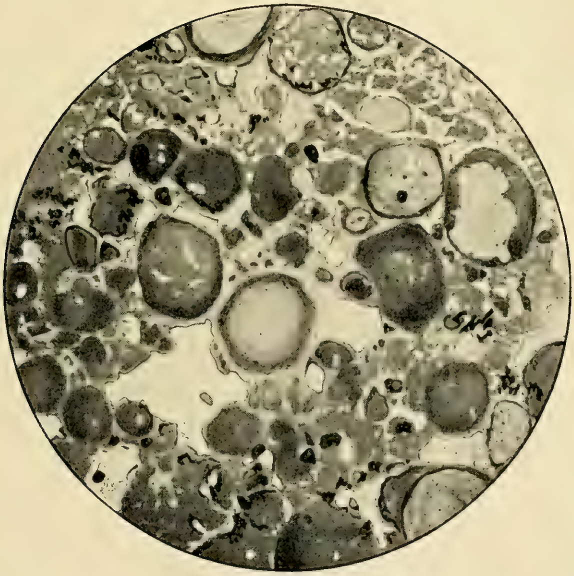

1. Grey rock from 'Khyber Pass', Warwick East, Bermuda. × 8·5.
2. Phosphorite with Staffelite, Manhattan Shoal, near Paget Island, Bermuda. × 10.

(adapical) in position, in an *Echinocardium* the most strongly developed are situated almost entirely on the inferior (adoral) surface.

These contrasts, in common with most of the others, between the two great groups of Echinoids, are, to a considerable extent, bridged over by the Holectypoida. In view of the very scanty evidence available for a study of the actual acanthology of the group, the proportions of the tubercles have to be regarded as furnishing an index of the character of the radioles. The investigation may be taken along two lines; the characters of the individual tubercles, and their changes in proportion and structure in different parts of the same test, and the changes in the order of distribution of the tubercles on the plates, which appear on a comparison of different species and genera.

The importance of the arrangement of the primary tubercles, as a guide to genetic sequence, has not received the recognition it deserves. Most authors, when figuring new species of Echinoids, give an enlarged drawing of one or more interambulacral plates to show this feature, but the meaning of it is rarely emphasized in the text, and often, owing to the not infrequent irregularities of growth in individual specimens, the figure becomes positively misleading. Almost the only occasion of which I am aware, when this character was exhaustively studied for systematic purposes, was in a paper by Saemann and Dollfuss in 1861 (Bul. Soc. géol. France, ser. II, vol. xix), where a distinction was diagnosed between *Pygaster gresslyi* and *P. laganoides* (*P. morrisi* being united to the latter species) on the evidence of the tuberculation. It is very doubtful whether the arrangement of the tubercles in the Spatangids, or even in the 'Cassidulids', could ever be used for the purpose of accurate diagnoses of species or even genera, its extreme complexity and consequent tendency to irregularity rendering a study of the interambulacra in these forms somewhat bewildering.

In the more complex Regular Echinoids, and in all the Holectypoids, the primary tubercles occur in regular vertical series in the interambulacra. These series appear with marked regularity until the ambitus is reached, after which they disappear in a corresponding order. There is always one row, approximately median in its position in the half-interradius, which persists from the apex to the peristome, and is commonly more prominent than the others. The other series of tubercles may be described as occupying the *interradial* or *adradial* tracts, according as they occur on one side or the other of this median series. The irregularities of development, which occur naturally, become more frequent as the complexity of the tuberculation becomes more marked. For the most part the diagrams here given are generalizations, which omit the numerous individual peculiarities.

In the Holectypoida the tuberculation shows a progressive complexity of arrangement when it is traced from the Jurassic to the Cretaceous representatives. As Saemann and Dollfuss showed in the paper already referred to, the value of this feature as a specific index depends very largely upon the age of the individual—a question often difficult to solve in the case of fossil forms. Far more evidence than I have yet been able to procure is necessary before the tuberculation can be made a reliable specific character. There is, however, in this branch of study, more possibility than in most other aspects of the Echinoidea, of tracing recapitulation during individual development. When A. Agassiz (in the *Revision of the Echini*) and others have shown that in, for example, a post-larval *Echinolampas*, each interambulacral plate bears a solitary tubercle (so passing through a '*Cidaris*'-stage'), it is at least probable that a study of the tuberculation of young stages in the less highly specialized Holectypoida will afford a useful guide to a determination of relationship. In this paper the feature is treated from a generic rather than a specific standpoint. After a description of characteristic types has been given, some general deductions as to the phylogenetic meaning of the various characters will be indicated.

II. THE TUBERCULATION IN CHARACTERISTIC SPECIES.

1. Pygaster semisulcatus (Phill.).

(*a*) *The Structure of the Tubercles.*[1] (Fig. 1, A.)

The primary tubercles are small on the adapical surface, prominent, but still small, on the ambitus, and but little larger adorally. The greater breadth of the scrobicules in the last-named region makes the tubercles there appear considerably larger than they are in reality.

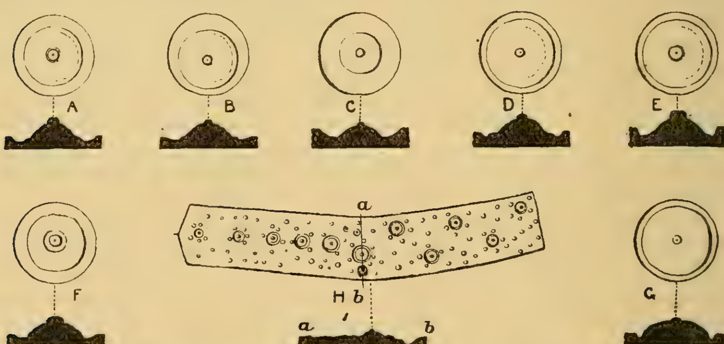

FIG. 1. Diagram showing the comparative structure of the tubercles (in plan and section) in the Holectypoida. A, *Pygaster semisulcatus*; B, *P. umbrella*; C, *P.* '*morrisi*'; D, *Holectypus hemisphæricus*; E, *Anorthopygus orbicularis*; F, *Discoïdea cylindrica*; G, *Conulus albogalerus*; H, plate 17 from an *Holectypus depressus* (and section along line *a–b*), showing socketed tubercle. [The tubercles represented (except in H) are all from the ambitus.]

Adapically the tubercles are smaller on the interradial than on the adradial tracts. The *scrobicule* is circular, very shallow in adapical tubercles, more deeply excavate in those of the adoral surface, where the scrobicules of adjacent tubercles are often confluent (or separated by a low, smooth ridge) transversely, but never vertically. The *scrobicular ring* is very irregular and indistinct. The *basal terrace* is

[1] The terminology employed is that standardized by Bather in his monograph on the Triassic Echinoderms of Bakony, 1909, p. 61.

well marked. The *boss* rises in an S-curve from the vertical edge of the terrace. It is always in the centre of the scrobicule. The *parapet* is but slightly raised above the *platform*, and both are smooth. The *mamelon* is small in proportion to the size of the boss, but almost covers the platform. It is roughly spherical, and has a small, circular *foramen*.

(*b*) *The Arrangement of the Tubercles.* (Fig. 2, A.)

As in all the Holectypoida, the plate next the apical system has only one tubercle, subcentral in position. In *Pygaster* the first four or five plates may retain this primitive character. The tubercles of this first series occur on every plate from apex to peristome, and, from the second plate downwards, are all towards the adoral margin of the plate in position, though never far from the centre. On the interradial tract there appear, in a persistent sequence as the transverse diameter of the plates increases, new tubercles, which develop into horizontal as well as vertical lines. Their position is midway between the adapical and adoral margins of the plates, a feature which distinguishes them clearly from the excentric main series. On the adradial tract there is a corresponding growth of fresh tubercles, but these develop into a different order. The first formed adradial tubercle is quite near to the adapical margin, while the second is equally near to the adoral. This zigzag horizontal arrangement is maintained, however many vertical rows of adradials may be developed. A study of the diagram will render the arrangement more intelligible than a detailed description. The disappearance of the rows of tubercles, after the ambitus is passed, is definitely in the inverse order of their appearance, on both the adradial and interradial tracts.

This method of arrangement is the simplest and most typical of those found among the Holectypoida. It results in an appearance as of broken horizontal lines of tubercles in the middles of the interambulacra, and of massed arrays of oblique series along the adradial regions. The tendency to a degeneration, or rather a lack of development, of the large radioles in the adapical interradial tracts, which is so prominent a feature in such genera of Regular Echinoids as *Cœlopleurus*, is thus seen to be present in *Pygaster*.

2. Pygaster umbrella, auct.

(*a*) *The Structure of the Tubercles.* (Fig. 1, B.)

The primary tubercles are small and inconspicuous on the adapical surface, except those round the periproct. Adorally they are considerably larger, and increase steadily in size almost to the margin of the peristome. The *scrobicule* is practically flush with the test-surface adapically, and but little more excavate below. The *scrobicular ring* is even less marked than in *P. semisulcatus*. The *basal terrace* and *boss* are similar to those in that species, but smaller in proportion, even adorally. The most significant feature of distinction between the tubercles of the two species is that in *P. umbrella* the boss is not in the centre of the scrobicule (in adoral tubercles), but tends towards the adoral side of the centre. The excentricity is not great, but is a persistent feature, and one which suggests a comparison with the extreme excentricity of the bosses on some parts of the tests of

Spatangids. The *platform* and *mamelon* are like those of *P. semisulcatus*, save for their smaller proportions to the rest of the tubercle.

(*b*) *The Arrangement of the Tubercles.* (Fig. 2, B.)

Though fewer in number and less regular in size, the tubercles in *P. umbrella* follow the same plan of arrangement as do those of *P. semisulcatus*. On the zigzag series of the adradial tracts, a curious, but apparently constant, irregularity in the order of the appearance of the vertical rows occurs. After the proximal series of adapically situated tubercles has appeared, the next to develop is series *three*, also adapical. Not for a plate or two do these two series become separated by the delayed appearance of the adorally placed series *two*. The same anomaly occurs in the growth of the next pair, and the retention of the principle of inverse order for their disappearance on the adoral surface results in a similar irregularity of the series in that region.

The incoming of irregularity in the tuberculation seems somewhat significant in view of the fact that the crowding of the tubercles is less marked in this species than in any others of the genus. It is not surprising to find trifling disorder appearing when the tubercles are minute and numerous, but in this case there seems no other reason for its presence but some fundamental tendency in evolution. *Pileus pileus*, which is also a Corallian form, and closely allied to *Pygaster*, seems to show a similar tendency, although I have not been able to examine any specimens which show the tuberculation clearly. *Pygaster macrocyphus*, from the Kimmeridge Clay, undoubtedly has an exactly similar irregularity, and it may be that these late *Pygasters*, with the periproct passing farther and farther from the apex, are showing in the tuberculation that plasticity of development which often accompanies or precedes the differentiation of new types. It would, however, be premature to discuss here the possible outcome of this reawakening of evolution in the genus.

3. Pygaster 'morrisi',[1] Wright. (Fig. 1, C.)

The group to which *P. laganoides*, *P. gresslyi*, and *P. truncatus* belong is one which was separated from the true *Pygasters* by Pomel (*Classification méthodique*, 1883) under the generic or sub-generic name of *Macropygus*. Previously both Desor (*Synopsis*) and Cotteau (*Echinides de la Sarthe*) had expressed the opinion that the group, while admittedly possessing peculiar features, did not merit generic distinction. Little support or comment has been given to Pomel's resuscitation of Desor's disowned name *Macropygus*, but the considerable differences from the typical forms that the three species referred to above exhibit might, perhaps, warrant its retention in a sub-generic sense. In no particular is this difference more clearly shown than in the character of the tuberculation. Instead of the shallow, broad scrobicules of *P. semisulcatus*, these parts in *P.* (*Macropygus*) '*morrisi*' are narrow and deep, so deep that the top of the mamelon is often but little above the

[1] I do not wish here to express an opinion as to the distinction or identity between this species and *P. laganoides*, Agass., but use Wright's name to indicate that the specimens I have examined are all from British localities.

general level of the test. The difference in size between the tubercles of the adapical and adoral surfaces is hardly appreciable, and they are closely packed over the whole test.

The principle of their arrangement is, however, exactly similar to that in *P. semisulcatus.*

4. Holectypus hemisphæricus (Desor).

(*a*) *The Structure of the Tubercles.* (Fig. 1, D.)

There is a very marked disparity in size between the tubercles of the adapical and those of the adoral surface in this species, the former being less than half the dimension of the latter.

The *scrobicule* is circular and moderately excavate, but the *scrobicular ring* is poorly developed. The *basal terrace* is even more abruptly marked off from the floor of the scrobicule than in *Pygaster.* Its diameter is but little less than that of the scrobicular circle, so that the *boss,* which is fairly high, almost fills the scrobicule. This feature is more noticeable adapically than adorally, since in the latter region the area of the scrobicules is increased rather more than that of the bosses. The *mamelon* is minute and perforated, but, in spite of its small size, almost entirely covers the narrow, uncrenelated *platform.*

(*b*) *The Arrangement of the Tubercles.* (Fig. 2, C.)

The general plan of the tuberculation is the same as that observed in *Pygaster semisulcatus*, except that, in spite of the considerably smaller size of an adult *H. hemisphæricus*, it normally bears more vertical series of tubercles per plate than the larger *Pygaster.* The specimen on which the diagram is chiefly founded shows a feature, present in only a few of those that I have examined, which seems significant. On the adradial tract of pl. 14 (marked with a cross in the figure), it will be noticed that, in place of the two adapically and adorally situated tubercles which go to the formation of the zigzag arrangement, *three* distinct tubercles are present. Trifling though this irregularity appears, it would seem (especially in view of its occurrence in several specimens), to have some phylogenetic significance. The triple arrangement of the tubercles becomes the rule in *Conulus*, as will be seen later, and here, in the Inferior Oolite, there seems to be a precocious tendency in some specimens of *H. hemisphæricus* to assume characters which do not become general until the Middle Cretaceous.

5. Holectypus depressus (Leske).

There seem to be two very distinct types of *Holectypus* passing under this name, one from the Inferior and Great Oolite, and the other from the Cornbrash. At present, however, I do not feel justified in distinguishing the two forms by name, especially as this paper is not systematic in purpose. The Inferior Oolite specimens are usually small, and their tuberculation is practically identical with that of *H. hemisphæricus.* There is one very notable feature which distinguishes both *H. depressus* from the last-named species, this being the relative number of plates above and below the ambitus. A comparison of the two figures (2, C and D) will make the contrast clear. In *H. depressus*, as soon as the ambitus is passed, the plates of the adoral surface rapidly become large, and therefore few in number, whereas they were peculiarly narrow on the adapical surface.

The specimens of *H. depressus* from which Fig. 2, D was constructed were all the large, Cornbrash forms. It will be seen that the arrangement of the tubercles is of the normal *Pygaster* type. There are, however, some features in the details of their structure which are worthy of more detailed description. (See Fig. 1, H.)

The proportionately greater size of the tubercles of the adoral surface, and especially of their scrobicules, when compared with those of the adapical region of the test, is more marked in this species than in *H. hemisphæricus*, chiefly on account of the much larger area occupied by each adoral plate. Apart from the extreme and *Pygaster*-like size of the adoral scrobicules, the details of tubercle-structure are alike in the two species. But on the adapical surface, on the plates which are about midway between the apex and the ambitus (pls. 8–17 in the diagram), a curious feature, unique as far as any other species I have examined are concerned, makes its appearance.

In the line of the central row of primaries, and between the main tubercle and the adoral margin of the plate, there occurs a small tubercle sunk in a deep socket. The details of the scrobicule and boss of this supernumerary tubercle seem identical in every way with those of the main series, but, owing to the obliquity of the floor of the socket, the tubercle points slantingly in an adoral direction. At first sight the socket looks like the open pit of a *sphæridium*, but, apart from the fact that it is nowhere near the peristome, the presence in it of a perfectly normal tubercle precludes the possibility of its having this function. The other, and more feasible, suggestion which its appearance provokes, is a comparison with the sunken, oblique major tubercles of the interpetalous regions of some of the more highly specialized Spatangids. The details of the relations and structure of this peculiar feature will be understood more clearly by an examination of Fig. 1, H, than from verbal description. I have not found any trace of a corresponding feature in the *H. depressus* from the Inferior Oolite.

In addition to this anomalous series of additional tubercles, it will be noticed, on reference to Fig. 2, D, that in the same region of the test some of the granules rise to the importance of actual tubercles. These extra tubercles, indistinguishable structurally (except in point of size) from the ordinary serial primaries, are always developed on or near to the central line of the plate, and to the adapical side of the main tubercle. The presence of these hypertrophied secondaries is again a precocious feature. In *Discoïdea* and *Conulus* they are typical and numerous, but the Cornbrash *H. depressus* is the only Oolitic form in which I have observed them.

6. Discoïdea cylindrica (Lam.).

(*a*) *The Structure of the Tubercles.* (Fig. 1, F.)

The disparity in size between the tubercles of the adapical and adoral surfaces reaches its extreme (for the Holectypoida) in *Discoïdea.* Not only are those of the upper surface small and inconspicuous in themselves, but a considerable increase in the number and size of the granules helps to give this part of the test an almost uniformly granular appearance. In the smaller species of the genus, such as *D. subucula*, this feature is carried so far that, except in very well-preserved specimens, it is practically impossible to distinguish between the tubercles and the granules. In *D. cylindrica* the distinction is rather more apparent. The main row of first-formed tubercles is considerably more clearly marked than the lateral series on the upper surface, and is situated on a prominence of the test which often becomes a carina passing vertically down the median line of each interambulacral plate. On the adoral surface the tubercles are much larger, and are all of approximately equal size. As will be seen by reference to the figure, the structure of an individual tubercle is very like that in the previously described genus, save that the basal terrace is peculiarly prominent and the platform very broad. It should be noted, however, that the adapically situated tubercles have practically no scrobicule, a fact which renders their separation from the granules additionally difficult.

(*b*) *The Arrangement of the Tubercles.* (Fig. 2, F.)

The diagram for this species is an actual copy of the tuberculation of one specimen — a beautifully preserved example of the *forma depressa* — in the collection of Mr. G. E. Dibley, F.G.S. It was found in the zone of *Holaster subglobosus* at Burham, Kent. It will be seen that the usual order of horizontal rows on the interradial, and of oblique rows on the adradial, tracts obtains in this species. There is a marked increase in number (as well as in size) of the tubercles at and below the ambitus, but these very rapidly disappear when traced towards the mouth, so that the adoral surface is but sparsely tuberculate over most of its area. In addition to the increase in size and number of the normal tubercles at the ambitus, many of the granules (which are usually disposed in more or less transverse lines in this genus) become exalted to the rank of tubercles, giving an appearance of double horizontal rows of tubercles on each plate in this region. Often these supernumeraries are quite as large as the original tubercles, although, for the sake of clearness, they are represented as dots in the diagram.

7. Anorthopygus orbicularis (Grateloup).

(*a*) *The Structure of the Tubercles.* (Fig. 1, E.)

The most striking contract between the tuberculation in this genus and that in those already described lies in the fact that the tubercles of the adapical surface are hardly distinguishable from those of the adoral surface in point of size. In this the genus recalls the sub-genus *Macropygus*, but the equality in size is yet further noticeable than in that Upper Jurassic series. The *scrobicules* are rather more deeply excavate than in *Holectypus*, and the *mamelons* considerably larger in proportion, but otherwise there are no important differences in structure.

(*b*) *The Arrangement of the Tubercles.* (Fig. 2, E.)

For a long time, even after I had become familiar with the order of the tuberculation in *Conulus*, I was unable to satisfy myself as to the manner of its arrangement in *Anorthopygus*. Not only were the sutures between the plates obscure in all the specimens available, but there seemed no trace of a central median series passing vertically

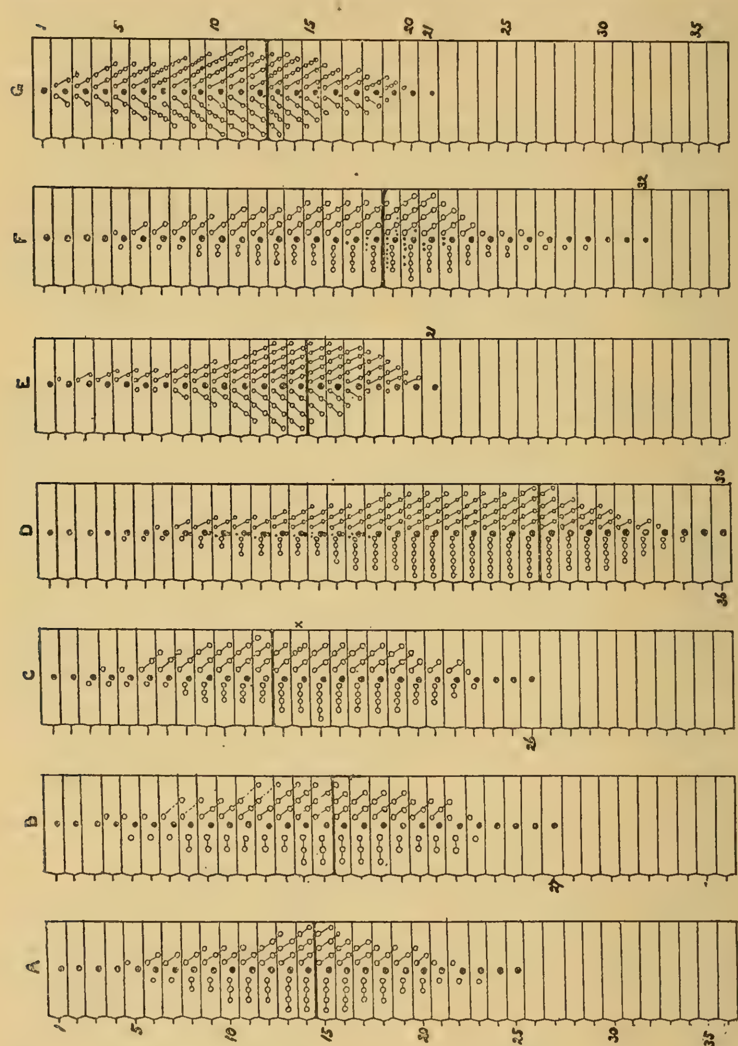

FIG. 2. Diagram showing the comparative arrangement of the tubercles (in a half-interradius) in the Holectypoida. A, *Pygaster semisulcatus*; B, *P. umbrella*; C, *Holectypus hemisphæricus*; D, *H. depressus*; E, *Anorthopygus orbicularis*; F, *Discoïdea cylindrica*; G, *Conulus albogalerus*. [The thick line represents the ambitus. The relative proportions of the tubercles are not indicated.]

from apex to peristome. It was only after persistently recurrent examination, and the drafting of frequent, often varying, diagrams of each specimen, that the system became manifest. One reason for its obscurity lies in the fact that the tubercles of the median series are placed very near to the adoral margins of the plates, and so lose the prominence which comes of isolation. The other, and most important, reason, is the order of position of the tubercles on the interradial tracts of the plates. An examination of one interambulacral plate of this species shows the tubercles to be arranged in two alternating horizontal lines, reaching from the adradial to the interradial sutures, and so closely packed that there is little room for granules between them. This is due to the presence of oblique pairs of tubercles on the *interradial*, as well as on the adradial, tracts; the adoral situation of the central series bringing those tubercles into a horizontal line with the lower members of the zigzag couples. The importance of this arrangement lies in the fact that the interradial tract, instead of being relatively poor in tubercles, becomes almost as thickly covered with them as the adradial portion. This is in striking contrast to the features of all the previously described forms, but affords a link with the genus next to be described.

8. Conulus albogalerus, Leske.

(*a*) *The Structure of the Tubercles.* (Fig. 1, G.)

In this genus the difference in the proportionate diameter of the tubercles of the upper and lower portions of the test is not so pronounced as in *Discoïdea*, but more so than in *Anorthopygus*. The retention of a well-marked scrobicule in the adapically situated tubercles, and the reduction of the 'granules' to the nature of pits, renders the upper ones very obvious, in spite of their usually low relief. The *scrobicule* is circular, quite deeply excavate in adoral tubercles, and well-marked, though shallow, in those of the adapical surface. The *boss* rises almost directly from the scrobicular circle with a sharply convex outline. On the adoral surface the boss rarely exceeds in height the depth of the scrobicule—adapically it usually projects slightly above the ring. The *platform* is broad, without a marked parapet, and quite smooth. The mamelon is small and has a deep central *foramen*.

(*b*) *The Arrangement of the Tubercles.* (Fig. 2, G.)

Although considerably more complex in order of sequence, the tubercle series in *Conulus* are far more readily traceable than in *Anorthopygus*. This is due to the more nearly central position (in a vertical sense) of the tubercles of the main series. Although these are often smaller than the lateral tubercles, and never larger, their isolation and position render them useful indices of the boundary between the adradial and interradial tracts. Except in very young forms of this species (and in moderately small specimens of *C. subrotundus*) there are rarely more than two plates at the apex which bear only one tubercle. There is thus a marked acceleration in the rate of appearance of the tubercles—even more than in the case of *Anorthopygus*. As in that genus, the interradial series of tubercles are oblique, as well as the adradial ones. But while in *Anorthopygus* there are never more than the necessary two tubercles in the oblique line, in *Conulus* three, or even four, may appear. The couple nearest the median series is, however, usually only dual in its composition. There is a greater tendency for this multiplication on the adradial than on the interradial tracts, and the oblique series are more closely packed in the former area. A few scattered supernumerary tubercles always appear near the ambitus, but these are not so numerous, nor so largely developed, as in *Discoïdea.*

III. THE TREND OF EVOLUTION IN THE TUBERCULATION.

In the descriptions of characteristic types just completed, there are two features which stand out pre-eminently as fixed and uniform. These are, the smooth, uncrenelated character of the summits of the tubercles, and their occurrence in regular vertical series which appear and disappear towards the two poles of the test in inverse order, leaving one central and persistent series which alone occupies some of the latest formed (adapical) and most reduced (peristomial) interambulacral plates. The universality of this unituberculate character of some of the plates throughout the group is an indication of its primitive position among the Irregular Echinoids, a belief which is confirmed by the fact that the number of plates which retain this character is less in the Cretaceous than in the Jurassic species. With the possible exception of the Echinonidæ and some of the genera allied to *Caratomus,* it would seem that, in adult specimens, no plates with a single tubercle remain.

But against these two persistent features may be placed two of equal importance, but exhibiting a progressive character when traced through the group. These are the relative proportions of the tubercles of the upper and lower surfaces of the test, and the distribution and number of the tubercles on any individual ambulacral plate. In these features the main lines of change seem to be maintained with considerable regularity when regarded stratigraphically. In the *Pygasters*, and especially in those from the Inferior Oolite, the distinction in size between the tubercles of the two surfaces s hardly appreciable. There is a greater density of packing adorally, but little actual difference in the diameter of either scrobicule or boss. In the later (Upper Jurassic) *Pygasters* this similarity is less pronounced, the adoral tubercles showing a marked increase in size, both actual and relative. In *Holectypus* the change is carried further. The number of adorally situated tubercles decreases, but their size increases in an almost inverse proportion in *H. depressus*, while the adapical tubercles are small and often imperfectly developed. In *Discoïdea* the tendency reaches its maximum, a few series of large tubercles existing adorally, while adapically the tubercles and granules can hardly be distinguished from one another. *Conulus*, and still more *Anorthopygus*, seem not to respond to the tendency in so marked a degree, but, as these genera do not appear to have any direct genetic relationship with *Discoïdea*, but rather to be an offshoot from Upper Jurassic *Holectypi* or even *Pygasters*, this fact does not interfere with the general principle.

In the peculiar Cenomanian form, *Anorthopygus*, the tuberculation has reverted (or at least shows a likeness) to the original *Pygaster*-feature of equality all over the test. This archaic trait seems to accord well with the retention of the periproct on the adapical surface. *Conulus* follows with a fresh tendency to irregularity, more of relief than of diameter, in the development of the tubercles. It may be noted that this slight contrast in size is also met with in the very closely allied genus *Pyrina*, the character of whose tuberculation seems, in most respects, intermediate between that of *Anorthopygus* and *Conulus*.

In the details of tubercle-structure the change would appear to have been from the concavo-convex outline of a boss standing freely in a large scrobicule, to the purely convex outline of a boss rising almost directly from the scrobicular circle. Coupled with this change is a lessening of the relative size of the mamelon, and a shallowing or even partial atrophy of the scrobicule.

When the arrangement of the tubercles is considered, a far more striking progression becomes apparent. In a young *Pygaster semisulcatus* many of the interambulacral plates support but one tubercle each, while there are usually three or four, often more, plates at each pole, which, even in adults, remain unituberculate. The arrangement of the additional tubercles is different on the two sides of the median row, being horizontal interradially and oblique adradially, the adradial tract of the area thus becoming comparatively densely tuberculate.

In *Holectypus* the number of additional tubercle series increases, but always on the same plan of arrangement as in *Pygaster*, and leaving the interradial tracts relatively bare of tubercles, a feature betokening the persistence of a tendency most strongly marked in the Regular Echinoids. *Discoïdea* carries on the sequence, but amplifies and elaborates it by the addition of many extra tubercles at and near the ambitus.

This group of forms, which is typified by the three genera *Pygaster*, *Holectypus*, and *Discoïdea*, may be taken as forming, broadly speaking, a genetic series.

In the case of *Anorthopygus* and *Conulus* a great difference is found. *Anorthopygus*, although resembling a *Pygaster* in many of its features, shows not merely an increase in the number of tubercles on each plate, but a uniformity of distribution of those tubercles by the change from the horizontal to the oblique order in the disposition of the interradial series. In addition to this, an acceleration in the growth of the tubercles appears, very few plates, whether adapical or adoral, retaining the primitive unituberculate habit. In *Conulus* we seem to have the same tendency to reduce the relative size of the adapical tubercles, which appeared in the *Pygaster–Discoïdea* series, working on an *Anorthopygus*-like arrangement of the tubercles. It seems impossible to maintain a natural separation between the 'Echinonidæ' and 'Echinoconidæ' in the feature of tuberculation, as in most other details of structure.

IV. SUMMARY.

It may be taken that the general tendency of the evolution of surface ornament (and therefore of the radioles) in the Holectypoida was a dual one. The large tubercles become gradually restricted to the adoral surface, and often reduced in number, while the actual density of the tuberculation increases. This increase is attained, either by a simple multiplication of the normal vertical series, as in *Discoïdea* (this being sometimes associated with the transformation of granules to tubercles at the ambitus), or by a more uniform distribution of those series over the area of the plates, and the frequent substitution of two tubercles in the place of one, as in *Conulus*. Both these types of change lead away from the primitive, 'Regular' condition of tuberculation, and trend towards the Clypeastroid and Cassidulid arrangement.

In view of the fact that, in almost every detail of comparative anatomy, the Holectypoida show a retarded evolution, it may be considered that the sequence of changes reviewed above actually represents, in a dilatory and extended manner, the process which, at one or more stages of geological history, produced a uniform and packed tuberculation from the solitary series of large tubercles which characterize the Cidaridæ.

Finally, I wish to express my thanks to Messrs. G. E. Dibley, Ll. Treacher, and T. H. Withers for the loan or gift of specimens which were invaluable in the construction of the diagrams.

III.—What is Laterite?

By L. Leigh Fermor, A.R.S.M., D.Sc., F.G.S., Geological Survey of India.[1]

Contents.

I. Introduction.

Few natural mineral products have aroused more general interest or been more provocative of discussion amongst geologists than that superficial rock-formation so typical of the tropics known as laterite. This material excites interest not only because of its chemical composition, but also on account of its wide distribution. It has been recorded, for instance, from tropical South America (e.g. the Guianas and Brazil), Central Africa (e.g. Guinea and East Africa), the Seychelles, India, the Malay Peninsula, the East Indies, and Western Australia. Many papers have been published dealing with its distribution, composition, and also its origin, to explain which many hypotheses have been invented.

Owing to the large number of occurrences of manganese-ore found in India in association with lateritic rocks,[2] I had, when working at

[1] Published with the permission of the Director, Geological Survey of India.

[2] To prevent this casual allusion to the subject of Indian manganese-ores giving rise to one of those misconceptions which, once formed, are so difficult to eradicate, I must state at once that the lateritic manganese-ores are, as a rule, of small importance compared with those of the Archæan areas.

the Indian manganese-ore deposits, many chances of striking a field acquaintance with laterite. Consequently, following the fashion of theorizing about laterite, I took the opportunity, in my memoir on the Manganese-Ore Deposits of India,[1] of expressing my own views, at the same time summarizing some of the theories previously advanced, especially with reference to Indian laterite. Concerning the origin of this rock I advanced the views (1) that rocks of more than one origin were included under the term *laterite*, (2) that in discussing the origin of this rock geologists had not always recognized this fact, and (3) that consequently the divergent theories put forward were in some cases invented to explain dissimilar occurrences. Further, the opinion was expressed that no profit could be derived from the further discussion of this question unless each author discussed a specific occurrence, of which a detailed description was at the same time given, so that no confusion should arise in the future. An actual case was then discussed, showing that two parts of one deposit of laterite have probably been formed in two different ways—one by the alteration of rock in situ, and the other by chemical deposition from a body of water.

In this chapter (p. 370) the term *laterite* was defined implicitly, but not explicitly, in the following passage:—

"This rock consists essentially of a mixture of hydrated oxides of iron and alumina, with often a considerable percentage of titania,"

this definition being intended to apply to all varieties of laterite formed in situ, but not to such varieties of the so-called low-level laterites as are of detrital origin, nor to any detrital or reconstructed varieties of high-level laterite; *it is only to laterites formed in situ that the present paper applies*, except where otherwise stated.

I may quote also another passage (p. 379), which does not advance any theory as to the origin of laterite, but states what I believe to be the *result* of lateritization of a rock. The passage is as follows:—

"It is also generally recognized that the formation of this type of laterite involves the disappearance, probably in solution, of the silica, lime, magnesia, and alkalies, of the original rock, with the concentration of the oxides of aluminium, iron, titanium, and sometimes manganese, to form laterite."

In holding these views I was, of course, but repeating Professor Bauer's[2] and Sir Thomas Holland's[3] ideas on the composition of laterite, and consequently on the definition as to what is laterite that naturally follows.

During 1909 and 1910, however, current geological literature was enlivened by two discussions about laterite: one of them, in the pages of this Magazine, referring to the use of the words *laterite* and *bauxite*; and the other relating to a paper entitled "The Origin of Laterite" read before the Institution of Mining and Metallurgy by Mr. J. Morrow Campbell.[4] As many of the participants in these discussions do not seem to have given sufficient attention to the views of Indian geologists on a rock which is, after all, primarily an Indian

[1] Mem. Geol. Surv. India, xxxvii, ch. xix, pp. 370–89, 1909.
[2] Bauer, *Neues Jahrb. für Min.*, etc., ii, p. 163, 1898.
[3] Holland, Geol. Mag., Dec. IV, Vol. X, pp. 59–69, 1903.
[4] Trans. Inst. Min. Met., xix, pp. 432–57, 1910.

rock, it seems to me desirable to develop what I think are the general ideas of Indian geologists on this question.

I propose to deal in this communication only with the *nomenclature of laterite* and to avoid as far as possible any discussion on its origin, and consequently I will first summarize the discussion that has taken place in the pages of this Magazine.

II. The Previous Discussion.

On pp. 100–3 of his work *The Geology of the Goldfields of British Guiana* (1908) Professor J. B. Harrison describes under the name of laterite certain residuary earths of which analyses are given, and which are obviously not true laterites in the sense outlined above. This work is reviewed in vol. vii of the Bulletin of the Imperial Institute, 1909, pp. 133, 134, a protest, in my opinion both justifiable and necessary, being raised by the reviewer against Professor Harrison's use of the word *laterite*. The reviewer says—

"The exact sense in which it is used is not defined, but the weathering products included under it appear to be in all cases ferruginous and siliceous clays. . . . These can scarcely be laterites in the modern sense of the word, which should be restricted to that product of weathering in hot moist climates which contains free aluminium hydroxide. The analyses of laterites proper usually show excess of alumina with silica as a subordinate constituent, though a considerable amount of iron and titanium oxides may be present."

Mr. J. B. Scrivenor[1] objects to the reviewer's attempt to restrict the meaning of the word *laterite*, regarding it as impracticable, and putting forward the interests of engineers as follows:—

"The reason of this is that the term 'laterite' has been used, in the Malay Peninsula at least, for many years by a large body of engineers for what are essentially masses of iron oxide replacing portions of weathered rock and filling fissures in such rock near the surface. This (Malayan) laterite is most abundant in weathered schists, and is largely used for public works. Small quantities of aluminium hydroxide may or may not be present in these masses of ironstone, but that question is of no immediate importance to the engineer, who values the stone for its hardness."

The material referred to in this passage is probably identical with the rock I have designated *lateritoid*[2] amongst the Indian lateritic rocks in order to indicate its resemblance to, and yet difference from, the more typical laterites (*infra*).

Mr. Scrivenor's letter leads to a reply from Mr. T. Crook,[3] of the Imperial Institute, who quotes Buchanan's original definition, and, remarking that the author of the term clearly distinguished iron-ore from the laterite in which it occurred, objects to the application of the term to *iron-ores* and *ferruginous clays*. Incidentally Mr. Crook remarks—

"It is a complex product, essentially characterized by the presence of free hydrated alumina, but usually containing also notable amounts of titanium and iron oxides, whilst free silica is generally present, and hydrated silicate of aluminium is not necessarily absent. The amount of iron oxide is very variable, but when it becomes excessive it usually separates out in the form of concretionary iron ore."

[1] Geol. Mag., 1909, p. 431.
[2] Mem. Geol. Surv. India, xxxvii, p. 381, 1909, and *infra*.
[3] Op. cit., p. 524.

In a second letter [1] Mr. Scrivenor, in order to illustrate the confusion surrounding the use of the term *laterite*, calls attention to the opinions of Dr. Maclaren [2] and Mr. Mennell [3] that an alternation of wet and dry seasons is necessary for the formation of laterite, and produces statistics of rainfall at Malacca to show that at that place there is no such alternation of seasons. And, whilst he admits that the rock called *laterite* by engineers in the Federated Malay States is *ironstone* deposited in weathered rocks, Mr. Scrivenor maintains that there exists in the State of Malacca an occurrence of rock that agrees with Buchanan's definition of laterite. He concludes by conjoining the doubt raised by Mr. Kilroe,[4] as to the necessity of tropical conditions for the formation of laterite, with his own deduction that an alternation of wet and dry seasons is unnecessary.

In another letter Mr. Scrivenor [5] replies to Mr. Crook to the effect that the essential point of Buchanan's original definition of laterite is that laterite sets when exposed to the air. Hence, if Crook's dictum that laterite must contain free aluminium hydroxides is to be accepted, he must prove that the setting of laterite is due to the dehydration of aluminium hydroxides and not to that of hydroxides of iron, as has been previously held. Mr. Scrivenor thinks that we can dispense with the term *laterite* altogether, as having now too loose a meaning, and use the term *bauxite* instead, for, according to passages he quotes from Holland and H. and F. J. Warth, laterite and bauxite are essentially similar.

Dr. J. W. Evans [6] now comes to Mr. Crook's assistance to combat Mr. Scrivenor's suggestion referred to above, and maintains that in India the term *laterite* is still applied, both in scientific, technical, and popular language, in the sense in which it was used by Buchanan over a century ago. He gives recent literature on the subject, and summarizes matters in the following clear words:—

"As a result of the work that has been done it is found that the chemical composition of laterite varies within wide limits according to the nature of the original rock, so that it is not necessarily the same as that of bauxite. One feature, however, remains constant, the small amount of combined silica in proportion to the alumina present, and it is in this respect that laterites differ from clays, which also occur as tropical decomposition products and are sometimes incorrectly described as laterites. If, again, the amount of ferric oxide is large, it is apt to form ferruginous concretions, which are commonly referred to as *lateritic iron ore*."

Mr. Crook [7] next returns to the attack and objects very strongly to Mr. Scrivenor's proposed misuse of the term *bauxite*, and denies that this word is yet available for petrographical use, maintaining that the non-existence of the compound $Al_2O_3 2H_2O$ as a mineral must first be definitely established.

Mr. Scrivenor,[8] in a further communication, replying to Dr. Evans, reiterates his point that the term *laterite* must not be held to imply the presence of free aluminium hydroxides in quantity; he states that

[1] Geol. Mag., 1909 p. 574.
[2] Op. cit., 1906, p. 546.
[3] Op. cit., 1909, p. 350.
[4] Op. cit., 1908, p. 539.
[5] Op. cit., 1910, p. 139.
[6] Op. cit., p. 189.
[7] Op. cit., 1910, p. 234.
[8] Op. cit., p. 336.

he finds free aluminium hydroxide in weathered granite, in kaolin, and in slate, as well as in all the Malayan laterites.

Dr. Evans[1] then allows the permissibility of using the term *bauxite* as a commercial mineral term to apply to laterites exceptionally poor in silica and in iron, provided it is understood that it is not to be employed as a rock name.

Mr. Scrivenor[2] replies to Mr. Crook in the same part of this issue, and quotes Lacroix as saying with regard to *bauxite*, "C'est en réalité une véritable roche." At the same time Mr. Scrivenor quotes an experiment in which he obtained over 13 per cent of alumina from decomposed granite, which should therefore, according to the definition advocated by Crook and Evans, be designated laterite, although no one in the Malay States regards it as such.

The correspondence in the pages of this Magazine ends here, for the time at least; but Professor Harrison, apparently under the stimulus of the original Imperial Institute review and of the subsequent discussion, from which he has quietly held aloof, has meanwhile had carried out a series of chemical analyses of the residual earths of British Guiana, which he describes in conjunction with Mr. K. D. Reid, in a paper extending into three numbers of this Magazine.[3] This paper is one of considerable importance, as it furnishes valuable material for the discussion of the composition of tropical surface decomposition products. Incidentally I may remark that it seems in my opinion to justify in full the objection advanced in the Imperial Institute review to Professor Harrison's use of the word *laterite*, for not more than a very few of the rocks and soils analysed are worthy of this name, such terms as *lateritic soil* and *clay* being more suitable.

III. The Nomenclature of Laterite.

In the sequel I propose to discuss Professor Harrison's paper at greater length, but it is first necessary for me to advance my own views on the subject. During recent years I have had field experience in various parts of the peninsula of many occurrences and varieties of Indian laterite. I have examined rocks that I regard as true *laterites* in the Balaghat and Jabalpur districts of the Central Provinces, in the Belgaum and Satara districts of the Bombay Presidency, in the Portuguese territory of Goa, and in the Sandur Hills in Madras; whilst of the type of lateritic rock I call *lateritoid* I have seen occurrences in the Singhbum district of Bengal, in Jabalpur, in Goa, in the Sandur Hills, and in the districts of Chitaldrug, Kadur, Shimoga, and Tumkur in Mysore; and, finally, I have examined the *lithomargic decomposition products* with a little laterite of the Nilgiri Hills. The consideration of these occurrences and of the specimens obtained therefrom, and also the work, published and unpublished, of such of my colleagues as have had extensive experience of laterite, particularly that of Sir Thomas Holland and Messrs. Hayden and Middlemiss, have led to very definite ideas as

[1] Geol. Mag., 1910, p. 382. [2] Op. cit., p. 384.
[3] 1910, pp. 439–52, 488–95, 553–62.

to which materials should, and which should not, be designated by the term *laterite.*

Difference between Laterite and Clay.—In the discussion summarized above three points are taken into consideration. Mr. Crook lays stress on the presence of free aluminium hydroxide, Mr. Scrivenor on the suitability of the rock for building purposes, whilst Dr. Evans lays stress on the small amount of combined silica in proportion to the amount of alumina present. In Dr. Evans' view lies the key to the question, I think. One should not decide whether a given rock is laterite on the basis of the presence or absence of alumina in quantity, but on the presence or absence of any considerable proportion of combined silica. Combined silica means the presence of kaolin or lithomarge, and the larger the amount of such material the closer does the rock approach a clay in composition. Now clays[1] are to be regarded as the end products resulting from one mode of superficial decomposition of rocks, and laterites as the end products of another totally distinct mode of decomposition. When a rock breaks down into a *clay* hydrated aluminium silicate is to be regarded as the pure end product, all oxides being removed in solution. When a rock is converted into *laterite*, on the other hand, the reverse holds; aluminium and other silicates are decomposed, and the silica is removed in solution, presumably in the colloidal form, whilst the oxides of iron, aluminium, titanium, and manganese, which were relatively soluble under the clay-forming conditions, are relatively insoluble under laterite-forming conditions. The oxides of calcium, magnesium, sodium, and potassium are apparently soluble under both sets of conditions. I do not propose to advance here any reasons to account for these two diverse modes of surface alteration of rocks, nor to say anything about the conditions, whether climatic or organic, that bring them about, but to deal only with the results of such changes. *Pure clay*, then, is hydrated aluminium silicate, whilst *pure laterite*[2] is a mixture of one or more, or all, of the oxides of iron, aluminium, titanium, and manganese, more or less hydrated, which I refer to in this paper as the lateritic constituents.[3] Manganese oxide is a somewhat exceptional constituent, and when present usually

[1] i.e. clays formed in situ, as distinguished from those deposited as aqueous sediments.

[2] F. W. Clarke holds similar views, as may be judged from the following quotation from his *Data of Geochemistry*, pp. 417–18 (1908): "Whatever its derivation may be, whether from rocks in place or as a transported sediment, *true laterite* [my italics] is essentially a mixture of ferric hydroxide, aluminium hydroxide, and free silica in varying proportions. To laterite in situ this statement applies very closely; detrital laterite is usually contaminated by admixtures of clay. Just as in the formation of kaolin, the process of laterization may be complete or partial, the typical product appears only when the alteration of the parent rock has gone to the end. Then the silicates seem to be completely broken down, whereas in kaolinization a stable, hydrous silicate remains." Mr. J. M. Campbell's definition (loc. cit., p. 437) is also similar; he mentions manganese, titanium, and phosphorus, in addition to the constituents named by Clarke.

[3] Other related oxides, such as Cr_2O_3, have been found in laterite, and are to be regarded as true lateritic constituents. See Mem. Geol. Surv. India, xxxvii, p. 378, and *infra* of this paper.

segregates into masses of comparatively rich manganese-ore, as a rule either psilomelane or pyrolusite.[1]

Typical Laterite.—We may accept, then, that *true laterite* (or *laterite proper*) is a hydrated mixture of oxides of aluminium, iron, and titanium, of extremely variable composition, and showing every gradation from ferruginous laterite almost free from alumina to aluminous laterite almost free from iron. Such laterites are often sufficiently pure to be termed respectively iron-ore and aluminium-ore, which seem, at least in some cases, to be the result of segregative tendencies acting on a more homogeneous form of laterite, doubtless under the influence of percolating water. When pure enough to be used as aluminium-ore the laterite is usually known as *bauxite*.[2]

As examples of typical laterites, reference should be made to the analyses given in two papers by Sir Thomas Holland[3] and Dr. W. Dunstan[4] respectively, although it should be noted that the samples represent the paler and more aluminous varieties, as they were taken with a view of testing the Indian laterites as a source of aluminium: in order to give a thoroughly sound idea of the composition of Indian laterites, it would be necessary to select for analysis another series of samples illustrating the ferruginous varieties. The consequence is that the analyses referred to all show high percentages of alumina, ranging from 31·37 per cent to 67·88 per cent, and it may be the consideration of this series of analyses that has led the mineralogists at the Imperial Institute to lay such stress on the essential presence of alumina in laterite. The amount of ferric oxide present in these samples ranges from 0·44 per cent to 40·18 per cent, but samples could easily be selected running much higher in this constituent.[5] The titania ranges from 0·04 per cent to 13·76 per cent, the combined water from 16·81 per cent to 33·74 per cent, and the silica from 0·05 per cent to 19·32 per cent. Apart from three samples showing 10·75 per cent, 14·58 per cent, and 19·32 per cent SiO_2, however, the amount of silica is never more than 4·68 per cent, and in all but five cases does not even reach 3 per cent.

Quartzose Laterite.—Accepting the definition of pure laterite given earlier, it is evident that if a lateritic rock be markedly siliceous, it will need special scrutiny and consideration before it can be admitted as a laterite. The silica may be present in two principal forms, namely, as *quartz*, either residual from the original rock, or secondary, and as *lithomarge* or kaolinite. If present as quartz, then

[1] The Indian manganiferous laterites have been discussed elsewhere (Mem. Geol. Surv. Ind., xxxvii, pp. 380–9), and they need not enter further into the discussion here, although they are probably of greater importance and wider distribution than is generally recognized.

[2] I use this word in a petrographical sense, concerning which see Section IV of this paper, *infra*.

[3] "The Occurrence of Bauxite in India": Rec. Geol. Surv. Ind., xxxii, pp. 178–80, 1905.

[4] "Report on Laterites from the Central Provinces": ibid., xxxvii, pp. 215, 216, 1909.

[5] The third group of analyses by H. and F. J. Warth shows, however, three true laterites containing 47 per cent to 56 per cent of Fe_2O_3, with 33 per cent to 26 per cent of Al_2O_3. See *infra*.

the rock is evidently a *quartzose laterite*, which would graduate with increase in the amount of quartz into a *lateritic sand* or *sandstone.* Such a quartzose laterite might result from the action of lateritizing processes on a rock containing free quartz, such as granite or gneiss, the original quartz being then one of the insoluble constituents. If, however, the quartz is of secondary origin, as in some of the so-called laterites of Professor Harrison, then it is obvious that the lateritizing processes have not acted normally, for this quartz should have been removed in solution on the breaking up of the silicate containing it. In fact, its presence indicates that the process by which the original rock has been altered cannot be accurately described as a lateritic one and the resultant rock as laterite, in the sense of p. 460. In any case, such a rock should be regarded as but imperfectly-formed laterite, requiring a qualifying adjective, such as *siliceous*, before the word *laterite*.

Lithomargic Laterite.—If the silica is present in the combined form, it indicates the presence of kaolin or lithomarge, and consequently that the process of lateritization of the rock has, again, not been pushed to a finish, and that this rock also is an imperfectly-formed laterite, requiring a descriptive adjective, such as *lithomargic*. With any large quantity of combined silica present, calculation would show that there was a larger amount of lithomarge than of free oxides and hydroxides, and the rock would then be correctly designated a *lateritic lithomarge.*[1]

Pisolitic and Oolitic Rocks.—Amongst laterites and the related rocks pisolitic and oolitic forms are moderately common. The *pisolitic* and *oolitic* bauxites are true *laterites*, as also are some of the pisolitic iron-ores. But the *pisolitic* and *oolitic* manganese-ores at present known are *lateritoids*,[2] and they are, it is interesting to note, also the most aluminous of the aluminous lateritoid ores (see analyses Nos. 9, 10, 14, on p. 1188, loc. cit., of ores from Kumsi manganese mine in Mysore, showing 12 to 18 per cent of Al_2O_3). Whilst many of the concretionary iron-ores are true laterites, certain deposits of pisolitic limonite, such as those forming part of the laterite formation[3] near Katni in the Jabalpur district,[4] or such as the pisolitic limonite cementing the bauxite conglomerate of Yeruli in the Satara district,[5] may have been deposited chemically from bodies of water, on the analogy of the Swedish lake ores. Such lateritic deposits, in cases where there is a considerable degree of probability, might suitably be termed *lake laterite*. Under this term would also be included any laterites formed by chemical deposition in bogs after the manner of bog iron-ores. By admixture of the iron hydroxides, at the time of deposition, with mechanically deposited sand and clay, *siliceous lake laterites* would be formed, and if the amount of siliceous material were excessive the

[1] An analogous expression is *bauxitic clay* used by T. L. Watson in his account of the "Bauxite Deposits in Georgia", Bull. No. 11, Geol. Surv. Georgia, p. 52, 1904.

[2] Mem. G.S.I., xxxvii, p. 381, 1909; and *infra*.

[3] See *infra* for the use of the term *laterite* in a stratigraphical sense.

[4] Mallet, Rec. G.S.I., xvi, p. 103, 1883.

[5] Mem. G.S.I., xxxvii, p. 375.

rock would be related to the detrital laterites referred to in the next paragraph. Compared to the true laterites, the lateritoids, and the detrital laterites, however, the lake laterites are probably of small importance in India.[1]

(*To be continued.*)

IV.—On the Relation of the Glacial Drift to the Raised Beach near Porth Clais, St. Davids.

By Arthur L. Leach, F.G.S.

During a recent examination (August, 1911) of the glacial drifts in the neighbourhood of St. Davids, I have noticed some glaciated surfaces on boulders of the raised beach in a section on the coast near Porth Clais, where the relation of the glacial Boulder-clay to the raised beach is so clearly shown that (pending a fuller description of these deposits) the importance of the section seems to justify a preliminary notice.

The raised beach of the Gower Peninsula has been described by Mr. R. H. Tiddeman,[2] who obtained definite proof that the beach was pre-Glacial in the sense that it always lay below the glacial drift in that district. The deposits associated with the raised beach are grouped by Dr. A. Strahan[3] into a 'Raised Beach Series' composed of three distinct members. The following brief description of this series, as it is displayed in Gower, is taken from a paper

[1] I must point out here the logical sequence of the adoption of this term *lake laterite*. If one is to apply the term to pisolitic iron-ores that have been deposited by chemical precipitation from a body of water, and are, in addition, associated with bodies of typical laterite, it is difficult to avoid its extension to include those deposits of iron-ore, manganese-ore, and bauxite that have been formed in an identical manner, but are not associated with lateritic rocks. All the deposits classed as *bog iron-ores* and *lake ores* in textbooks on ore-deposits could then be called *lake laterites*, and also the *sedimentary manganese-ore deposits*. The lake iron-ores of Sweden, the bog iron-ores of various parts of Northern Europe, the manganese deposits of the Caucasus, and perhaps the iron-ores and bauxites of Antrim, must then all be classed as *lake laterites of various ages*. Further than this, if my theory of the origin of the manganese-ore deposits of the gondite series of the Central Province is correct (loc. cit., pp. 308–19, 365), they are to be regarded as in part (the *primary ores*) the product of metamorphism of a series of manganese-oxide sediments, chemically deposited in lake basins, and interlaminated with mechanically deposited sands and clays, the whole series representing a metamorphosed Caucasus (as has been noticed by De Launay in his recent work *La Géologie et les Richesses, Minérales de l'Asie*, p. 698, 1911). These Indian deposits are therefore *metamorphosed lake laterites*. However, I do not wish to give this extended meaning to the term, but insert this footnote merely to draw attention to the real significance of the existence of the lake laterites, if any such can be proved to exist. There is to me nothing objectionable in this term *lake laterite*, nor in its possible wide extension as outlined above, if fellow-geologists think it desirable. This possibility merely serves to point out the inherent chemical relationship between the typical laterites and many deposits of iron, manganese, and aluminium ores all over the world, which, whilst differing from true laterites in mode of occurrence and formation, are yet related to them through the lake laterites as defined in the body of this paper.

[2] Geol. Mag., Dec. IV, Vol. VII, 1900, p. 441.

[3] *The Country around Swansea* (Mem. Geol. Surv., 1907).

by Dr. Strahan on the geology of South Wales[1] in the Jubilee volume of the Geologists' Association.

"1. The highest member, or head, is a talus of angular fragments of limestone, obviously derived from the neighbouring cliffs, and containing no other rocks.

"2. Under this and mingling with it is a foxy-red sand, very variable in thickness, and containing an occasional snail-shell. This is evidently a blown sand.

"3. The lowest member is a layer of well-rounded pebbles of limestone, crowded with shells of recent species. . . ."

Dr. Strahan gives a list of these shells, and states that the shingle rests on a water-worn platform about 10 to 15 feet above the present level of the shore (or about 25 feet above Ordnance Datum), and that the head and the shingle are always firmly cemented by carbonate of lime. The proof of the pre-Glacial age of this series of deposits depends on Mr. Tiddeman's observations at several points on the Gower coast, where glacial deposits were found frequently to rest upon but never to underlie the raised beach deposits.

In South Pembrokeshire I have observed the 'platform' and its associated deposits at several points, but although the shingle, blown sand, and head always occupy the same relative positions as in Gower, the three members are seldom well displayed in any one section, and in no case has a glacial deposit yet been observed clearly resting upon the raised beach series. Mr. E. L. Dixon, who has mapped the raised beach in this district, remarks that at Bullum's Bay (Caldey) "the glacial deposit appears to overlie the raised beach, though the exposure is obscure, and the evidence of superposition is not so conclusive as in Gower".[2] Again, in the Milford Haven district the platform has nowhere been found in clear association with glacial deposits.[3]

Near Porth Clais in North-West Pembrokeshire, the stratigraphical relation between the raised beach and the glacial deposit is perfectly clear and conclusive. It is of interest to note that the evidence is to be found in the immediate vicinity of a section of the raised beach and head, figured by Prestwich in his great paper on "The Raised Beaches and Rubble Drift or 'Head'".[4] The sketch for the figure must have been taken from a point very close to the place where the glaciated surfaces are now exposed.

Prestwich mentions two raised beach sections, one "a short distance west of Porth Claus [Clais] Harbour", the other "half a mile W. of Porth Claus [Clais] Harbour". The first is illustrated by a figure which shows merely head resting on "Beach consisting of subangular fragments of Cambrian and pre-Cambrian Rocks, granite, veinstones, porphyry, white quartz pebbles, and a few flint pebbles". The second exposure, which was pointed out to Prestwich by Dr. Hicks, is described simply as "Beach 8 feet thick and covered by 15 feet of Head". One of these exposures, probably the second, must be

[1] See *Geology in the Field*, 1910, pp. 851–2.
[2] *Summary of Progress for 1905* (Mem. Geol. Surv.), p. 70.
[3] E. L. Dixon, *Summary of Progress for 1906* (Mem. Geol. Surv.), p. 63.
[4] Quart. Journ. Geol. Soc., vol. xlviii, 1902, p. 293.

identical with that described by me, but Prestwich drew no distinction between the head and the glacial drift.

About a quarter of a mile south-west of the little harbour of Porth Clais, near St. Davids, a mass of glacial drift forms a well-marked terrace, roughly semicircular in outline and convex towards the sea. In the low cliff or steep bank on the seaward margin of this terrace, which overlooks an inlet named on the 6 inch map Ogof golchfa, the glacial drift is seen resting in part on the solid rock and in part overlapping upon the raised beach (see Figure). From the western end a level rock-platform, about 15 feet above high-tide level, extends almost horizontally for about 50 yards across Lower Cambrian shales and sandstones, and then, rising slightly, passes over an igneous dyke (only a few feet wide) which has been planed down almost to the general level of the platform. A few yards further to the east a huge dyke fully 40 feet wide intersects the Cambrian shales, and the cleanly cut platform ends. Upon the platform rest many large well-worn boulders (closely resembling the beautifully ovoid boulders of the raised beach at Whitesand Bay, St. Davids) embedded

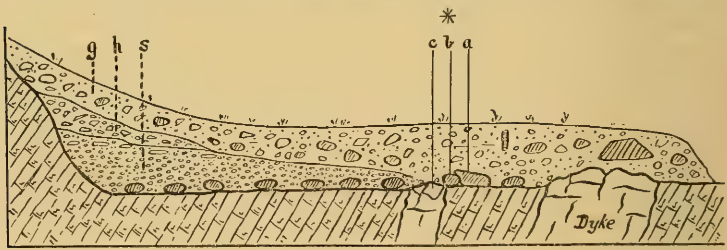

Diagram section of the Raised Beach and Boulder-clay near Port Clais, St. Davids. *g*, glacial deposit (Boulder-clay); *h*, head; *s*, stratified shingle and boulders of the raised beach; *a*, *b*, striated boulders of the raised beach; *c*, striated rock-surface.

in concreted beach shingle composed largely of flattish ovoid pebbles of various igneous rocks. The shingle, which is about 10 feet thick at its western end, contains many partly worn blocks of Cambrian shale and pebbles of sandstone, but igneous pebbles predominate, especially in its lower part, and the whole deposit, except the non-local boulders and pebbles, appears to be an old pebble beach such as might accumulate about high-tide level at the foot of cliffs composed of shales and sandstones with igneous intrusions. Upon the shingle lies head a few feet thick composed of angular debris from the rocks above. These two deposits are referable to the shingle and head of the Gower Raised Beach Series: the intermediate blown sand of Gower is not here represented. Over the head, and to some extent cutting into and mingling with it, lies a drift deposit (containing boulders), which I consider to be glacial and separable from the head, and to be directly continuous with Boulder-clay which some yards further east ploughs quite through the raised beach deposits and comes to rest on the solid rock. Although the western end of the section is inaccessible, it can be closely inspected across a fault-chasm a few yards wide, and the point of greatest interest (indicated by * in the diagram) where the glacial deposit rests on striated boulders is easily accessible. Here (see Figure) several boulders of the raised beach remain firmly cemented to the platform, but most of the shingle has been swept away, and the boulders are covered by yellowish clayey drift. The boulder (*a*) is a 'beach' boulder of greenish igneous rock (probably local), and its upper surface is smoothed, polished, and covered with well-marked striations, of which a few run irregularly, but by far the greater number run uniformly slightly west of a N.W. by S.E. line. Before my visit this striated surface was hidden by soil,[1] and its remarkable freshness is due to this protective covering. The boulder (*b*), an almost spherical mass of Cambrian purple sandstone, lies next to (*a*) and is also a raised beach boulder, but it has been long exposed to the weather and the glacial striations have almost disappeared. The block (*c*) is not a beach boulder, but a piece of the igneous dyke which here forms the platform of the raised beach. It has one smooth water-worn surface covered by striations, now partly obliterated by weathering. These boulders lie at the margin of the preserved portion of the raised beach. To the west, under the head and glacial drift, boulders and shingle extend continuously for more than 50 yards, but to the east there is nothing but Boulder-clay.

The glacial character of the deposit superposed on the raised beach is well-marked. It is an unstratified gravelly Boulder-clay packed with blocks and pebbles of Cambrian purple sandstone in great abundance, boulders and pebbles of local igneous rocks such as the pre-Cambrian granophyre (Dimetian), and the later norites and diabases of the St. Davids Head intrusive rocks, with flint pebbles and other rocks probably not of local origin. It contains well-striated pebbles, and one huge diabase boulder (weighing some tons) which projects conspicuously upon the seaward face of the drift is at least a mile from the nearest exposure of any similar intrusive rock. Since this deposit rests in part on a striated surface and contains striated stones and erratic boulders its glacial origin is clear.

The succession may now be compared with that on the Gower coast[2]—

Gower.		Porth Clais.
g. Upper or Post-Glacial Head.		*g*. [Not clearly represented.]
f. Glacial Beds.		*f*. Glacial Boulder-clay.
e. Lower Head.	Raised Beach Series.	*e*. Lower Head.
d. Blown Sand.		*d*. [Not present.]
c. Raised Beach Shingle.		*c*. Raised Beach Shingle.
b. Raised Beach Platform.		*b*. Raised Beach Platform.
a. Present Beach.		*a*. Present Beach.

I have recently found in this district a representative of the post-Glacial head, which will be described on another occasion. The agreement in general level of the raised beach in the two cases is very close, and differences such as the absence of shells and of

[1] The soil has been replaced upon the glaciated surface and covered by a large slab of rock. The point * is 20 yards west of the large angular boulder indicated in the diagram.

[2] See Mr. R. H. Tiddeman's figure reproduced in *Geology in the Field*, p. 852.

blown sand, the presence of abundant igneous pebbles, and the looser character of the shingle and head at Porth Clais as compared with Gower are due to local conditions. In Gower the Raised Beach Series accumulated on a limestone platform, bordered by a sandy shore, which subsequently yielded the blown sand, and overhung by limestone cliffs whence the angular debris or head was derived. Carbonate of lime was therefore abundantly present to supply the calcareous cement by which the shingle and head are firmly concreted. Near Porth Clais, on the other hand, where the rock-platform was cut in non-calcareous shales (penetrated by igneous intrusions), and shelved rapidly into fairly deep water, neither the shingle nor the head contained any appreciable amount of calcareous material, and these members are but loosely compacted. They were, therefore, readily broken up when the Boulder-clay passed over them, and, in fact, the head is only clearly preserved under the lee of the steep cliff on the west; elsewhere so much glacial material has become mixed with it that the two are not separable. From the evidence given above the raised beach near Porth Clais, in respect to its elevation, constituent members, and relation to the glacial beds appears to correspond with that of Gower, and is similarly pre-Glacial in the sense that it underlies the lowest visible glacial deposit. But the mode of transport of the large igneous boulders, which occur as erratics in the raised beach both here and in South Pembrokeshire, is a problem requiring further consideration, and if the solution be found in the hypothesis that they were transported by drifting boulder-bearing ice, then the formation of the raised beach must be associated with a climate sufficiently cold to permit large masses of shore-ice to form around the beach boulders, and to drift several miles southward along the coast. The glaciated boulders described in this paper were not striated by shore-ice, which admittedly can in Arctic regions [1] striate stones and the rock-platform beneath. The definite and uniform direction of the striations is against this view, and shows that they were caused by land-ice moving in from the W.N.W. (approximately), and moreover no striations can be observed on beach boulders which are not directly overlapped by the Boulder-clay.

Summary.

1. The raised beach near Porth Clais consists of shingle and large wave-worn boulders resting on a rock-platform, and overlain by angular head or rubble of local rocks.

2. Glacial drift (Boulder-clay) overlies the head at the western end of the section, and towards the east has ploughed into the raised beach and rests on the solid rock. Some of the boulders of the raised beach and a small piece of the rock-platform are definitely striated under the Glacial drift.

3. The raised beach is pre-Glacial in the sense that it underlies the Glacial deposit.

4. The raised beach contains non-local boulders which may have been transported by drifting shore-ice.

[1] Colonel H. W. Fielden, Quart. Journ. Geol. Soc., vol. xxxiv, p. 556, 1878.

V.—The Correct Technical Name for the 'Dragon-tree' of the Kentish Rag.

By F. H. Knowlton, M.S., Ph.D., United States Geological Survey, Washington, D.A., U.S.A.

THAT curious fossil organism, long known as the 'Dragon-tree', has been a puzzle to palæobotanists for almost three-quarters of a century. Bandied about among various monocotyledonous genera, then thought to be possibly related to the Cycads, and finally given a non-committal name that was without implication of kinship, though placed among the Cycads, it has at last, through the admirable research of Dr. M. C. Stopes,[1] been definitely allocated among the Conifers, and even among the higher members of that group. Dr. Stopes is certainly to be congratulated for having worked out its affinities in such a conclusive and convincing manner. It is to be regretted, however, that the scientific name she has finally adopted for the 'Dragon-tree' is not the one that is likely to meet the requirements of nomenclatorial permanency. The nomenclature of systematic palæobotany does not differ essentially from that of living plants, and must abide by the same rules.

The nomenclatorial history of the 'Dragon-tree' is briefly as follows: The first and most remarkable example was discovered in 1839 by W. H. Bensted,[2] and by him presented to the British Museum, where König gave it the manuscript name *Dracæna Benstedi*, apparently written on the specimen itself. This name was taken up by Morris[3] and by Mantell,[4] but it appears to have been first described and figured by Mackie[5] in 1862. In 1868 Carruthers[6] expressed the opinion that these stems were "more like those of a *Pandanus* than a *Dracæna*", but he did not change the name, nor did Gardner[7] in 1886 when he opined that they might belong to the Cycads. Apparently the status remained as above outlined until 1896, when Professor Seward[8] instituted for their reception the new genus *Benstedtia*, which he later tentatively placed among the Cycads. Seward described his new genus fully, but did not directly associate it with a species, though by citation its type was *Dracæna Benstedii*, König.

In 1900 Professor Fliche,[9] of Nancy, described under the new generic name *Coniferocaulon* certain casts of stems from the French Lower Cretaceous, which Seward[10] says "are, I believe, identical with those referred to *Benstedtia*". This generic identity of the French and English specimens is confirmed by Dr. Stopes, who, though calling the English stems *Benstedtia* throughout her paper, reaches the conclusion in the final paragraph that "Our plant, then,

[1] Geol. Mag., n.s., Dec. V, Vol. VIII, pp. 55–9, 1911.
[2] See his account, *Geologist*, vol. v, p. 336, 1862.
[3] *Cat. Brit. Fossils*, 1st ed., 1843, p. 7.
[4] *Petrifactions and their Teachings*, 1851, p. 49.
[5] *Geologist*, vol. v, pp. 401–4, pl. xxii, 1862.
[6] Geol. Mag., Vol. V, p. 154, footnote, 1868.
[7] Ibid. (3), Vol. III, p. 201, 1886.
[8] *Annals of Botany*, vol. x, p. 219, 1896.
[9] Bull. Soc. Sci., Nancy, (2), vol. xvi, p. 16, 1900.
[10] *Annals S. African Museum*, vol. iv, p. 35, 1903.

the *Dracæna Benstedii* of König, the *Benstedtia* sp. of Seward, is best designated by the name *Coniferocaulon Benstedii*".

The rules of nomenclature will not permit this combination, for if *Coniferocaulon* is congeneric with *Benstedtia*, it is antedated by four years and becomes a synonym of the latter. If these are not congeneric, then the type of *Benstedtia* cannot be taken from it, and the result becomes the same. Recapitulated, the correct name for the English 'Dragon-tree', together with its synonymy, stands as follows:—

BENSTEDTIA BENSTEDI (König), n.comb.

1896. *Benstedtia*, Seward, *Ann. Bot.*, vol. x, p. 219 [type *Dracæna Benstedi*, König].
1900. *Coniferocaulon*, Fliche, Bull. Soc. Sci., Nancy, (2), vol. xvi, p. 16.
1843. *Dracæna Benstedi*, König MS.: Morris, *Cat. Brit. Fossils*, 1st ed., p. 7 [*nomen nudum*]; 2nd ed., 1854, p. 8.
1851. *D. Benstedii*, König: Mantell, *Petrifactions and their Teachings*, p. 49.
1862. *D. Benstedii*, König: Mackie, *Geologist*, vol. v, pp. 401–4, pl. xxii.
1896. *Benstedtia* sp., Seward, *Ann. Bot.*, vol. x, p. 220, pl. xiv, fig. 3.
1911. *Coniferocaulon Benstedii* (König), Stopes, GEOL. MAG., N.S., Dec. V, Vol. VIII, p. 59, fig. (in text).

VI.—THE NAME OF THE 'DRAGON-TREE'.

By MARIE C. STOPES, D.Sc., Ph.D., F.L.S.

WHY should the 'Dragon-tree' have a name at all? Assuredly one of 'nomenclatorial permanency' is impossible for it, for the thing is not a recognizable species. Dr. Knowlton's note on the 'Dragon-tree' (*ante*) is an illustration of the application of the strict laws of nomenclature regardless of common sense. The object of my paper (GEOL. MAG., Dec. V, Vol. VIII, pp. 55–9, 1911) was to show that the plant for some time called *Benstedtia* is *not* a genus in the true sense of the word at all, as it is merely a bit of the woody trunk of one of the higher Conifers. So much Dr. Knowlton accepts—and then discusses its name in the same fashion as is used for true species.

As regards the name, I am sorry I did not make myself quite clear. It was perhaps unwise of me to have mentioned the name *Coniferocaulon* at all, but I thought that this non-committal pseudo-generic name ("the stem of a Conifer"), being already in existence, might be a convenient rubbish-heap for the temporary housing of such uncertain fragments as the 'Dragon-tree'. Dr. Knowlton's quotation hardly represents my attitude towards this name. I said, "Except for historical interest, and for the convenience of having a name by which to designate a special kind of cast of a genus known otherwise (compare the *Knorria*, etc., of *Lepidodendron*), there appears no reason now to give *Benstedtia* a generic name of its own."

My work on the specimen, which any botanist can confirm now I have found the simple method of dealing with such fossils, clearly and finally proved that the supposed genus is merely a bit of wood of a trunk of a Conifer. Dr. Knowlton himself says that the nomenclature of palæobotany "must abide by the same rules" as those applied to recent botany. No botanist gives a generic and specific name to a bit of bark or rotten secondary wood. Palæontology we know differs very much from modern biology in the nature of the specimens with which it has to deal; but even so, would a vertebrate palæontologist of any standing found a genus and species on the common leg-bone of a mammal because it was too decayed to recognize exactly to which mammal it belonged?

Dr. Knowlton, with the zeal for the technical application of their rules of nomenclature which characterizes a certain school of biologists in America, who take every opportunity these technicalities give them of renaming other people's species, has made himself responsible for *Benstedtia Benstedi*. A genus and species must be capable of diagnosis, and it now devolves on Dr. Knowlton to provide that diagnosis.

NOTICES OF MEMOIRS.

I.—Geological Survey of Southern Rhodesia.

THE following particulars are extracted from the Report of the Director, Mr. H. B. Maufe, for September to December, 1910 (Salisbury, Rhodesia, 1911):—

Headquarters have been established in Bulawayo for the purpose of working in co-operation with the geological and mineralogical section of the Rhodesia Museum. The provision of a suitable topographical map is a question of prime importance. The farm plans compiled by the Surveyor-General on the scale of 400 Cape roods to the inch form the most suitable available basis for the geological field mapping. They are often far from satisfactory as regards topographical details, and the geologist's time will frequently be taken up in inserting the more important surface features.

November and December were spent in actual field mapping in the Enterprise Goldfield, situated to the east of Salisbury. An area of 50 square miles was finished, and a further area traversed, but not completely mapped.

The Enterprise Goldfield lies in a district of metamorphic rocks, extending almost thirty miles slightly north of east of Salisbury, and measuring from north to south eight miles or more. On the north, east, and south it is bounded by granite, which is later than the metamorphic rocks and causes contact alteration in them. The metamorphic rocks are divisible into three groups, as follows:—

(1) A group consisting largely of epidiorite.
(2) An ironstone group, which also includes some limestones.
(3) A group of quartzites and conglomerates.

Each of these groups includes many varieties of rock, some of which occur in two or even three groups, but the groups as a whole are fairly well defined, and seem to correspond with the subdivisions described by Mr. F. P. Mennell in other parts of the country. The greater part of the metamorphic rocks are altered sedimentary rocks—altered conglomerates, sandstones, shales, and limestones. Up to the present the only igneous rocks met with which belong to the metamorphic series are the epidiorites forming the larger portion of group (1). Gold occurs in payable quantities in certain bands of schist intercalated in the epidiorites of group (1). Several mines working these bands are being energetically developed. The ironstone group, the argillaceous beds of which are often highly charged with sulphides, are being prospected at the present time, and gold is reported to occur in many parts of this group. Group (3), though bearing certain signs of mineralization, seem to have received little attention hitherto. Gold also occurs in quartz veins and stringers traversing the metamorphic rocks, and these are naturally not neglected.

Iron-ore (chiefly hæmatite) is abundant. The huge excavation in Iron Mine Hill on the eastern part of Learig Farm is said to be the work of natives, who formerly smelted the ore for their own use. Limestone is being burnt for lime at Chishawasha. Large deposits, partly magnesian, partly a pure lime, as shown by analysis published in the *Agricultural Journal* for November, 1910, occur on the south side of Kilmuir Farm. A talc-schist of a pleasant dull-green colour is being used successfully for internal decoration in the Chishawasha Mission. The stone, in spite of its schistose structure, carves easily and takes a good polish.

The rocks later in age than the metamorphic series are all of igneous origin. They comprise the granites, together with some allied plutonic rocks more basic in composition, and a younger group of dykes and irregular masses of dolerite. In addition to the immense masses of granite which fringe the district under description, smaller masses are intruded into the metamorphic rocks and frequently crop out in the vleis. Small masses of a more basic plutonic rock are occasionally found in similar positions.

The later dolerite dykes, which are intruded into the granite and metamorphic rocks alike, call for no further description here.

The structure of the metamorphic rocks is exceedingly complex. The rocks have been intensely compressed by forces acting in a north and south direction, and thereby been thrown into folds ranging east and west, but occasionally diverging as much as 20 degrees on either side of these points. The compression has been so intense that the limbs of the folds have been pressed together, and now dip at the same angle and in the same direction.

II.—British Association for the Advancement of Science, Eighty-first Annual Meeting, held at Portsmouth, August 30–September 6, 1911. List of Titles of Papers read in Section C (Geology) and in other Sections bearing upon Geology.

Presidential Address by *A. Harker, F.R.S.*

Clement Reid, F.R.S.—The Geology of Portsmouth and District.

Professor S. H. Reynolds.—Further Work in the Silurian Rocks of the Eastern Mendips.

Dr. A. R. Dwerryhouse.—The Glaciation of the North-East of Ireland.

Dr. W. F. Hume & J. I. Craig.—The Geological Period and Climatic Changes in North-East Africa.

Report of the Committee for the Collection, Preservation, and Systematic Registration of Photographs of Geological Interest.

Report of the Committee to consider the preparation of a List of Characteristic Fossils.

Report of the Committee to Investigate the Erratic Blocks of the British Isles and to take measures for their preservation.

Report of the Committee for the investigation of the Igneous and Associated Rocks of Glensaul and Lough Nafooey Areas, Co. Galway.

Joint meeting with Section E: Discussion on the Former Connexion of the Isle of Wight with the Mainland.

Professor J. W. Gregory, F.R.S.—Constructive Waterfalls.

Joint meeting with Sections K and E: Discussion on the Relation of the Present Plant Population of the British Isles to the Glacial Period, opened by *Clement Reid, F.R.S.*

W. B. Wright.—On the Lower Carboniferous Succession in the neighbourhood of Bundoran, S. Donegal.

W. B. Wright.—On the Occurrence of Submerged Forests in certain Lakes in Donegal and the Western Isles of Scotland.

A. R. Horwood.—On some new Rhætic Fossils from Glen Parva, Leicestershire.

A. R. Horwood.—On the Shell-layer in Mollusca. (See Geol. Mag., September, 1911, p. 406.)

Dr. W. F. Hume.—The First Meteorite Record in Egypt.

R. W. Hooley.—On the Discovery of Remains of *Iguanodon Mantelli* in the Wealden Beds of Brighstone Bay, Isle of Wight, and the adaptation of the pelvic girdle to an erect position and bipedal progression.

Professor E. S. Moore.—Siliceous Oolites and other concretionary structures in the vicinity of State College, Pennsylvania.

Professor E. S. Moore.—On the Pre-Cambrian Beds of Ontario.

Rev. A. Irving.—On the Occurrence of a Freshwater Limestone in the Lower Eocenes of the Northern Flank of the Thames Basin.

Rev. A. Irving.—A Remarkable Sarsen or Greywether.

T. Ross Thomson.—Wealden Ostracoda.

Report of the Committee appointed to enable Mr. E. Greenly to complete his researches on the Composition and Origin of the Crystalline Rocks of Anglesey.

Report of the Committee appointed to excavate Critical Sections in the Palæozoic Rocks of Wales and the West of England.

Report of the Committee appointed to investigate the Microscopical and Chemical Composition of Charnwood Rocks.

Report of the Committee appointed to enable Mr. C. Forster Cooper to examine the Mammalian Fauna in the Miocene Deposits of the Bugti Hills, Baluchistan. (See p. 473.)

Report of the Committee appointed to determine the precise significance of Topographical and Geological Terms used locally in South Africa.

Report of the Committee appointed to investigate the Fossil Flora and Fauna of the Midland Coal-fields.

List of titles of papers read in other Sections bearing upon Geology:—

Section A.—Mathematical and Physical Science.

Report of Committee on Seismological Investigations.

Professor H. H. Turner.—Note on the Periodogram of Earthquake Frequency, from Seven to Twenty Years.

Maxwell Hall.—Sunspots, Earthquakes, and Rainfall.
Professor O. Petterson.—Great Boundary Waves: Parallactic Tides set up in the Bottom Layers of the Sea by the Moon.

SECTION D.—ZOOLOGY.

Presidential Address by *Professor D'Arcy W. Thompson, C.B.*
Professor G. Elliot Smith, F.R.S. — The Origin of Mammals. Discussion—speakers: *Professor A. Keith, Dr. C. W. Andrews, F.R.S., Dr. Marett Tims.*
Professor Malcolm Laurie.—The Hypostome and Antennæ of a reconstructed Trilobite (*Calymene*).
Professor S. H. Reynolds.—Pleistocene Mustelidæ.
Dr. C. W. Andrews, F.R.S.—The Extinct Reptiles of the Oxford Clay of Peterborough.
Report of the Committee on the Index Animalium.
Dr. Elliott & Miss B. Lindsay.—Remarks on Boring Molluscs.

SECTION E.—GEOGRAPHY.

Professor J. W. Gregory.—Constructive Waterfalls.

SECTION H.—ANTHROPOLOGY.

A. L. Lewis.—Dolmens and Cromlechs.
Report on Artificial Islands in Scottish Lochs.
R. R. Marett.—Pleistocene Man in Jersey.
Dr. A. Keith.—Cranium of the Cro-Magnon Type found by Mr. W. M. Newton in a Gravel Terrace near Dartford.
Dr. A. Keith.—Remains of a Second Skeleton from the 100 foot Terrace at Galley Hill.
Dr. A. Keith.—Fossil Bones of Man discovered by Colonel Willoughby Verner in a Limestone Cave near Ronda, in South Spain.
R. R. Marett.—Cave-hunting in Jersey.
J. R. Mortimer.—Notes on the Stature, etc., of our Ancestors in East Yorkshire.
W. Dale.—Memorials of Prehistoric Man in Hampshire.
O. G. S. Crawfurd.—The Distribution of Types of Implements in the Early Bronze Age in Britain.
Report on Lake Villages near Glastonbury.
H. N. Davies.—Notes of Human Remains of ancient date found at Weston-super-Mare.
Rev. Dr. A. Irving.—Later Finds of Horse and other Prehistoric Mammalian Remains at Bishop's Stortford.
Report on the Excavation of a Prehistoric Site at Bishop's Stortford.

SECTION K.—BOTANY.

Professor F. W. Oliver, F.R.S.—The Life-history of a Pebble Beach.
Professor H. C. Cowles.—A Fifteen-year Study of Advancing Sand-dunes.
Dr. F. J. Lewis.—The Forest Stages represented in the Peat underlying the Moorlands of Britain.
Dr. M. J. Benson.—The Structure of a new type of *Synangium* from the Calciferous Sandstone Beds of Pettycur, Fife, and its bearing on the origin of the seed.

Dr. D. H. Scott, F.R.S.—A Palæozoic Fern and its Relationships (*Zygopteris Grayi*, Williamson).

Professor A. C. Seward, F.R.S.—A Petrified Jurassic Plant from Scotland.

H. Hamshaw Thomas.—Recent Researches on the Jurassic Plants of Yorkshire.

Miss T. Lockhart.—A Contribution to our Knowledge of the Formation of Calcareous Nodules containing Plant-remains.

III.—The Mammalian Fauna in the Miocene Deposits of the Bugti Hills, Baluchistan.[1]

Interim Report of the Committee, consisting of Professor G. C. Bourne (Chairman), Mr. C. Forster Cooper (Secretary), Drs. A. Smith Woodward, A. E. Shipley, C. W. Andrews, and H. F. Gadow, and Professor J. Stanley Gardiner, appointed to enable Mr. C. Forster Cooper to make an examination thereof. (Drawn up by the Secretary.)

THIS expedition arrived in Jacobabad in the middle of January, 1911, and after obtaining the necessary camels, stores, and servants, proceeded into the Bugti territory and arrived in five days at Kumbhi. Here the fossiliferous beds were located and four weeks spent in working out the exposures each side of Kumbhi. The beds were then followed out to the eastward round the Zen Koh range, with varying success, the strata in parts being much disturbed and unsuitable for the preservation of fossils.

During the last four weeks of the expedition an important bone-bed was discovered at Churlando of a different character of deposition to the other beds. Owing to the difficult nature of the excavation, the lack of suitable labour, and to the fact that very heavy rains delayed the work for a week, much still remains to be done in this bed, and the interesting specimens obtained warrant its further exploration.

A considerable collection of mammalian remains was obtained from the various localities which is now in process of development and cleaning in the laboratories of the Natural History branch of the British Museum prior to a detailed examination and description.

The fauna consists largely of Anthracotheres, of which group many species are represented in the collection. Remains of extinct orders of Rhinoceros are also common, including an interesting new genus now in process of examination.

Fragments of small Artiodactyles also occur, but owing to the character of the deposits small forms are seldom preserved. The condition of the remains is unfortunately poor as a rule, partly owing to the weathering and partly to the damage done by contemporary crocodiles at the time of deposition, the remains of these animals being abundant as well as the marks of their teeth on the fossils obtained.

The expedition received much kindness and help from the Government officials, as well as from the ruling chiefs of Dera Bugti.

[1] Read before Section C (Geology), British Association, Portsmouth, September, 1911.

REVIEWS.

I.—The Bighorn Coal-basin, Alberta, Canada. By G. S. Malloch. Memoir No. 9E, Geological Survey, Department of Mines, Canada. Ottawa, 1911.

THE Bighorn Coal-basin is situated in Western Alberta, and was named from the Bighorn range, an outlying portion of the Rocky Mountains that extends from the North Saskatchewan to the Brazeau River. The coal-bearing strata, known as the Kootanie Formation, are of Lower Cretaceous age, and occupy a basin with overlying Upper Cretaceous and Quaternary deposits. The older and underlying strata comprise Jurassic, Triassic, Permian (?), Carboniferous, and Devonian. The discovery of coal was made in 1906 by Mr. D. B. Dowling, and analyses proved that it was well adapted for use in locomotives. Moreover, nine workable seams with an aggregate thickness of 66 feet were subsequently proved, and as much as 88 feet is now recorded in a depth of 2,760 feet. The coal-seams are more regular than the intervening strata. The deposits were accumulated chiefly by rivers, but are in parts of lacustrine and marine origin. The coal was probably formed in peat-bogs. Mr. Malloch gives full particulars of the strata, with lists of fossils, pictorial views, and a geological map.

II.—History of Geology. By Horace B. Woodward, F.R.S., F.G.S. 8vo; pp. 154, 14 portraits. London: Watts & Co. Price 1*s*.

WHATEVER Mr. H. B. Woodward undertakes to do he does well. And in this little book one can clearly see that its omissions are due solely to the limit of its pages. It is full of information of the best and most instructive sort, and can be thoroughly recommended to the youth who after reading one textbook thinks he is master of his subject, or to the older and wiser student who always knows that he has still much to learn. Highly interesting, the reader glides along scarcely noticing that he is taking in intellectual nutrition all the time, and arriving at the end he promptly begins the book over again. The eight chapters are divided into Early Notions about the History of the Earth, the Founders of Geology, Geology in the early part of the Nineteenth Century, Principles of Geology, Surveys, Elucidation of the Older Geological Systems, Palæontology, Archæan and Metamorphic Earth-movements, and Petrology. A short Bibliography and an Index conclude the volume. We notice one atrocious word, 'seaquakes,' one omission, 'Timothy' instead of 'Timothy Abbott' Conrad, and one mistake, 'Richard' instead of 'David' Dale Owen; these we name merely for correction in the subsequent editions. Everybody who pretends to any interest in geology should read this book, and it might well be used in classes wherever geology is taught or referred to.

III.—The Nottingham Coal-field.

Ancient Historical Records relating to the Nottingham Coal-field, 1526 to 1600.—The Historical Manuscripts Commission have recently issued a Report on the Manuscripts of Lord Middleton of Wollaton Hall [Cd. 5567], 1911, price 3*s.* It is well printed (by the *Hereford Times*, Limited], well indexed, but badly sewn, the top sewing having entirely failed to hold the sheets.

In this volume of 746 pages is much interesting matter relating to the early history of the Nottingham Coal-field and indication of a vast deal more which it was impossible to print in a volume of this nature. We find accounts of the sinkings, levels, and getting day by day, with the quantities and prices, wages, and cost of plant. We have rules to be observed by miners in the coal-pits, proposals for carrying coal from Nottingham to London by sea via Hull, improved pumping machinery, and many other matters of considerable interest.

The rules to be observed are as follows:—

"*The Stevers'* [*sic*] *Charges.*

"This is our master's commandment that all you stovers of the feild shalle make your just account unto your undermen everye nowne and every nyght what you have gett and sould. For every tyme that you do mys, you must losse iijs. iiijd.

"And for every bourdenne of colles that you do sowfer to be borne from the feilde, you must losse xijd.

"And for everye bordenne of wood the like xijd.

"And that you shale make just messeures betwene the lord and the countre, to make to every halfe rooke[1] ix corfulle,[2] and to every three quarters xiij corfulle, and to every whole rooke xviij cor-full of just and good messeure without fraud, deseate or guile, as you will answere at your perille.

"And if aney one be takene with aney of the pit candels bearinge whome to his house [a fine of] iijs. iiijd.

"And if ane one be takene withe ane of the pit towles [= tools] in his howse, to losse iijs. iiijd.

"And if aney one be taken cuttinge of aney of the pit rowpes or withe aney in his howse, to lowse vjs. viijd.

"And if aney one be taken knotinge[3] in of ane worke, it is fellonie; the must b[e] used at the lordes plesure.

"And for every of these defaultes whosoever he is, it must be taken up [off] of his wages the next Seterday after.

"More, if aney mann do take ane of the lordes money without the comand of him or his offe[ce]res, to losse xs., and so to Departte the towne and the feyld."

Among the accounts are the following:—

"1548, January 19. Paid to Pole and his feylows for dryvynge of a thyrle [= shaft] in the newe leyvell, by daytale, for iiij dayes *dim.* [$=\frac{1}{2}$] . . . . iiijs. vjd."

[1] A rooke was $2\frac{1}{4}$ yards high and 1 yard square.

[2] The contents of a corf or basket.

[3] Knocking, beating down?

"March 2. Paid to Smaley and one with hym for ij dayes clevyng and makyng of pic-helves . . . . xvjd."

"June 15. Paid to Smaley for shotyng of a waloer[1] . iiijd."

"June 28. Paid to Burton, Baker, Nyxson and Hill, beyng dryven forth with the dampe of ther pit, for a day worke at the heye way xvjd."

"Dec. 24. Paid to the pit ryves in parte of recompence for ther paynes for gyeyng [=directing] the workes . . . . . xs."

In 1526 a collier seems to have got about thirteen rookes of coal per week, of which the hard was worth eighteenpence and the soft twelve shillings, but by 1548 "the softe cole goeth with the harde cole without anye diversitie of price", and "every rooke is ijs." In 1548 the cost of "syngkynge a pit" was "iiijs. the heght", but how much a 'heght' was in depth does not here appear.

IV.—Brief Notices.

1.—Geological Survey of Sidmouth and Lyme Regis.—A second edition has been issued of the Geological Survey Memoir on the *Geology of the Country near Sidmouth and Lyme Regis*, 1911, price 1*s.* 6*d.* This memoir contains a description of the cliff sections from Otterton Point by Sidmouth and Seaton to Lyme Regis, and of the inland country round Honiton and Axminster. The New Red rocks, the Rhætic beds, Lias, Gault, Upper Greensand, and Chalk are dealt with, and figures of many fossils from the famous locality of Lyme Regis are included. There are also numerous sections, and the superficial deposits, the landslips, and the economic geology are described. The work has been written by Messrs. H. B. Woodward and W. A. E. Ussher, with contributions by Mr. A. J. Jukes-Browne.

2.—"The Growth of a Crystal" was the subject chosen by Principal H. A. Miers for the Eighteenth Robert Boyle Lecture delivered at Oxford in May, 1911 (8vo, pp. 32, Henry Frowde, price 1*s.* net). This is an interesting and popular account (in the highest sense) of what is known concerning the general growth of crystals. Although the author refers to what may be called the vitality of a crystal, he points out that this "is not to be confounded in any way with that of a living plant or creature". Much remains to be done before the mysteries of the growth of crystals can be explained, but the author makes several suggestive remarks that may stimulate further research.

3.—Guide to the Exhibition of Animals, Plants, and Minerals mentioned in the Bible. British Museum (Natural History), Special Guide No. 5, 1911. Price 6*d.*—This work, which contains the latest information on the several subjects of which it treats, will interest a wide circle of general readers as well as students of natural history. The section on minerals has been contributed by the Director of the Museum, Mr. L. Fletcher, who remarks that scarcely any of the specimens mentioned in the Bible were found in Palestine or were

[1] ? straightening, a shaft-head wheel.

brought from localities now known, and that there is still great uncertainty as to the original signification of the Hebrew and Greek names. Most of the specimens were precious stones brought from other lands. The amethyst, beryl, sardonyx, emerald, and agate can be identified. The sapphire appears to have been lapis lazuli. It is doubtful whether the diamond was known when the precious stones in the breastplate of the High Priest were enumerated. Alabaster was an onyx-marble (calcium carbonate), and the material termed brass was generally bronze.

CORRESPONDENCE.

DREIKANTER.

Sir,—Permit me to apologize without delay to Mr. Grabham for having suggested that he was wrong in writing 'a dreikanter'. Whether I was myself in the wrong is another matter. Before venturing on any allusion to other writers I looked the word up, and if I was wrong after all, that fact only strengthens my argument. Surely my point is clear. What I object to is the use of foreign words instead of English ones, especially when accompanied by an alteration in their meaning. The fact that some of us occasionally fall into error in using such words was mentioned incidentally as an additional reason for avoiding them.

Perhaps I should add that I am not responsible for the terms 'tripyramidal' and 'triquetral': they have often been used to express the form of true 'Dreikanter', and those who wish to use that term for facetted pebbles of other shape may be recommended to read Professor J. W. Gregory's address on "The Scientific Misappropriation of Popular Terms" reported in to-day's *Times*.

September 2, 1911. F. A. Bather.

P.S.—In his "Observations on the Magdalen Islands" (Bull. New York State Museum, 149) just to hand, that excellent German scholar, Dr. J. M. Clarke, twice uses yet another variant, namely 'dreikant*n*er'.

September 23, 1911.

FORMATION OF LATERITE.

Sir,—After I forwarded to you Part II, "Microscopical Evidence," of my note on the "Formation of a Laterite from a practically Quartz-free Diabase", which was published in the August number of the Geological Magazine, pp. 353–6, I received from Messrs. Voigt and Hochgesang specially prepared sections cutting through both the diabase and its inner layer of laterite at their junctions.

The following is a short account of the contact between the diabase and its laterite crust:—

Nearing the margin of the undecomposed rock many of the cleavages and the lines of chemical weakness in the plates and prisms of felspar are seen to be filled with films of limonite and are bordered with minute scales of gibbsite.

These cleavage and other lines are still more clearly marked near to the margin, are eroded into and charged with decomposition-products, mainly scales of gibbsite, but with some opaque white and dust-like substances. As the junction is approached the larger felspar prisms and the aggregates of smaller ones gradually break up into small granular non-striated fragments lying in and surrounded by aggregates of scales of gibbsite, interspersed with more or less opaque dust-like substances. Many of the granules are eroded, and their contours remind one of those of sugar crystals dissolving in water. Here and there in the larger plates of felspar aggregates of scales of gibbsite form inlets.

The pyroxene masses in places are changed into aggregates of 'viridite' or of chlorite, but more often the cleavages of otherwise apparently unaltered augite are lined and filled with limonite. Nearer to the margin of the diabase this latter condition steadily increases until close to the contact of the rock and the laterite the masses of augite are changed into reticulations of limonitic products with small unaltered fragments of pyroxene.

Where the rock is actually changing to laterite, all the masses of its augite are altered into reticulations of limonitic oxides of iron with few remnants of more or less unchanged pyroxene, and with relatively few minute aggregates of scales of gibbsite and of dust-like opaque products.

The final change in the slices examined from felspars somewhat corroded to aggregates of gibbsite in parts of them occupied a breadth of less than ·2 of one millimetre, whilst in places, especially where the felspar lies in aggregates of small prisms, the change must be described as abrupt.

The distance between the apparently unaltered diabase and the lateritic aggregate of limonite and gibbsite with few minute fragments of unchanged felspar, some minute granules of secondary quartz, and grains of ilmenite varies in the specimens examined from 1·6 millimetres as a minimum to 3·9 millimetres, or to about one-seventh of an inch, as a maximum. Thus the actual change is mainly, although not entirely, a surface one, the alteration noticed along the cleavage and other lines in the inner parts of the diabase being of very subordinate importance to the superficial ones.

J. B. Harrison.

Science and Agriculture Department,
Georgetown, Demerara,
August 19, 1911.

OBITUARY.

SAMUEL CALVIN, M.A., LL.D.

Born February 2, 1840. Died April 17, 1911.

Samuel Calvin was born in Wigtonshire, Scotland, on February 2, 1840. He went with his parents to America when he was 11 years of age, and received his education at Lenox College, Iowa. When he was 24 years old he enlisted in the Army and served for a few months in the Civil War. He then became a teacher of science in

Lenox College, and afterwards principal of a ward school at Dubuque. In 1874 he was elected to a professorship of natural science in the University of Iowa. Here, at first, he had charge of botany, zoology, geology, and physiology. Later he was made professor of geology, a position which he filled with distinction until his death. He received from Cornell College the degrees of M.A. and LL.D., and from Lenox College the degree of Ph.D.

In 1892 Dr. Calvin was elected State Geologist of Iowa. This position he resigned in 1904 owing to the stress of other duties. However, in 1906, upon the resignation of Professor Wilder, he was again elected State Geologist, and continued to serve until his death. The Iowa Geological Survey under his directorship published about twenty volumes of reports dealing with the geology and mineral resources of the State. Of great scientific value have been his own contributions to the geology of Iowa, especially those papers which have added to our knowledge of the Pleistocene. His most recent scientific publications, which deal with the Aftonian mammalian fauna, have done much to unravel some of the difficult problems of Pleistocene palæontology. In all his scientific work he was thorough, no details were considered trivial; his one desire was to discover truth—to find any facts which could make knowledge clearer, broader, more definite. That he had the power to clothe his thoughts in beautiful language is clearly shown in all his writings.[1]

George F. Kay.

State University of Iowa.

JOHN ROBERT MORTIMER.

Born 1825. Died 1911.

By the death of John Robert Mortimer the geologists of East Yorkshire lose one of the few remaining members of their 'old guard'. Though the chief scientific work of his life was done in the domain of archæology, culminating five years ago in the publication of his great work entitled *Forty Years Researches in British and Saxon Burial Mounds of East Yorkshire*, Mr. Mortimer likewise rendered notable service to geology by his writings and, above all, by bringing together the unrivalled collection of fossils from the Chalk of the Yorkshire Wolds, now housed in the private museum that he built at Driffield.

Mortimer was born in the Wold village of Fimber, and dwelt there until manhood, when he shifted his residence to Driffield, a few miles distant, where the rest of his life was spent, and where he died, on August 19 last, at the ripe age of 86 years. When a child he was of delicate health; indeed, throughout life his health was never robust, but he was endowed with a tough vitality, mental energy, and an indomitable spirit which carried him through many troubles and remained with him up to the last. So lately as the present year he sent a paper to be read at the British Association meeting at Portsmouth, on "The Stature, etc., of our Ancestors in East Yorkshire". His business of corn merchant and maltster brought him in contact with

[1] Abridged from *Science*, N.S., xxxiv, p. 107. We are indebted to Mr. G. P. Merrill for a copy of this memoir.

all the people of the countryside, so that when anything rare or curious was unearthed he soon had news of it. By this means and by his long-continued excavations of the barrows and other prehistoric burial-places, he was enabled to accumulate a store of archæological material which is of peculiar value as a strictly localized record of the early races that inhabited the district.

During the years of his middle life Mortimer regularly attended the meetings of the British Association. He contributed papers on the Yorkshire Chalk to the Geological Society in 1869, 1875, and 1876, and to the Geologists' Association in 1877 and 1890. He also published several geological papers in the Proceedings of the Yorkshire Geological (and Polytechnic) Society. A complete bibliography of his writings is contained in an illustrated sketch of his life by Mr. T. Sheppard, F.G.S., which appeared in the *Naturalist* for last May (No. 652).

His wife, a daughter of the Rev. T Mitchell, vicar of Sancton and Holme-on-the-Wolds, died six years ago. They had a family of six children, five of whom survive them.

Mr. Mortimer was a man of impressive personality—tall, lithe, active in all his movements, and until a few months before his death almost untouched by age. His kindliness and his energy endeared him to all his numerous friends, and he has left a lasting memory in the district for which he had such a loyal affection.

G. W. L.

MISCELLANEOUS.

University of St. Andrews.—At the recent celebration of the five hundredth anniversary of the University of St. Andrews, the following geologists were admitted to the honorary degree of LL D.: Dr. John Horne, Professor A. G. Nathorst, Dr. J. J. H. Teall, Professor W. W. Watts, and Dr. A. Smith Woodward.

Erratum.—September Number, p. 400: Fig. 2 is printed upside down, reversing the relative positions of the saddles and lobes of the suture.

The Swiney Lectures on Geology.—In connexion with the British Museum (Natural History), Dr. T. J. Jehu, M.A., F.R.S.E., will commence a course of twelve *free* lectures on "The Natural History of Rocks" on Saturday, November 4, 1911: (1) Introductory; (2) Monday, November 6, "Eruptive Igneous Rocks"; (3) Tuesday, November 7, "Intrusive Igneous Rocks"; (4) Saturday, November 11, "Composition, Texture, and Structure of Igneous Rocks"; (5) Monday, November 13, "Derivative Rocks"; (6) Tuesday, November 14, "Organically-derived Rocks"; (7) Saturday, November 18, "Structure of Derivative Rocks"; (8) Monday, November 20, "Metamorphism"; (9) Tuesday, November 21, "The Metamorphic Rocks"; (10) Saturday, November 25, "Carbonaceous Rocks"; (11) Monday, November 27, "Chemically-formed Rocks"; (12) Tuesday, November 28, "Deposits formed on Land." At the Lecture Theatre of the Victoria and Albert Museum, South Kensington. Mondays and Tuesdays at 5 p.m., and Saturdays at 3 p.m.

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EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

ASSISTED BY

PROFESSOR J. W. GREGORY, D.Sc., F.R.S., F.G.S.
DR. GEORGE J. HINDE, F.R.S., F.G.S.
SIR THOMAS H. HOLLAND, K.C.I.E., A.R.C.S., D.Sc., F.R.S., F.G.S.
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HORACE B. WOODWARD, F.R.S., F.G.S.

NOVEMBER, 1911.

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THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE V. VOL. VIII.

No. XI.—NOVEMBER, 1911.

ORIGINAL ARTICLES.

I.—Upper Cretaceous Terebelloids from England.[1]

By Dr. F. A. Bather, M.A., F.R.S., F.G.S., etc.

(PLATE XXIV.)

IN April, 1879, William Davies published in the Geological Magazine (n.s., Dec. II, Vol. VI, pp. 145–8) a paper on "Some Fish Exuviæ from the Chalk, generally referred to *Dercetis elongatus*, Ag.; and on a new species of Fossil Annelide, *Terebella Lewesiensis*". Herein he discussed certain longitudinal or tubular agglomerations of fish-debris, originally named *Muræna* (?) *Lewesiensis*, by G. A. Mantell, but subsequently assigned by L. Agassiz to the fish described by him as *Dercetis elongatus*. References to the various papers and books in which these remains had been mentioned will be found in the paper quoted. From his profound knowledge of fossil fish Davies was able to show that these agglomerations contained the remains of more than one species of fish, and he considered that the fragments had been collected and affixed to their tubes by annelids allied to the modern *Terebella*. It is well known that some living species of that genus have similar tube-building habits, so that the suggestion made by Davies has been generally accepted, and the specimens in the British Museum on which he based his conclusions have since then been labelled *Terebella* (?) *Lewesiensis* Mantell sp.

The object of the present note is to make known some slight additions to our knowledge, and to discuss one or two points in the paper by Davies.

The specimens described by Mantell and Agassiz and the majority of those studied by Davies were composed of the debris of fish. In these specimens Davies pointed out diverse individual variations: some are of small scales, with few or no bones [B.M. 25875, 25876]; others of large or small scales associated with numerous small bones [B.M. 58259]; others, again, have assembled long fin-rays "arranged fairly in the direction of the long axis of the specimen", e.g. that figured in Dixon's *Geology of Sussex*, pl. xxxiv, fig. 5 [B.M. 25942], and the specimen 14 inches long, to which Davies specially referred [B.M. 58261]. The variation, however, is considerably more than this, for we now know of specimens from the Cretaceous rocks of England that have a tube of quite other composition. One specimen [B.M. A 1583], from the Cenomanian Grey Chalk of Folkestone,

[1] Published by permission of the Trustees of the British Museum.

appears to represent a tube composed of the small ossicles of starfish and brittle-stars. Other specimens, recently detected by Dr. Marie C. Stopes in the course of her work on the Catalogue of Cretaceous plants in the British Museum, have a very distinct tube composed of leaflets and fragments of bark of some coniferous tree or trees, either pine or fir. Finally, there are specimens which, in the words of Davies, "admirably show by impression the membranous or horny structure of the tube," yet "bear no indication of the attachment of any foreign substance".

Before entering on any speculation as to the specific distinctness or identity of these various forms, it may be well to set forth such definite facts and natural conclusions as are not already contained in the valuable paper by Davies. The tubes of different composition will be dealt with in order.

Tubes of Fish-debris.

'*Terebella*' *lewesiensis* (sensu stricto).

Diagnosis.—Tube of fish-debris, with diameter from 1 to 3 cm., and with a possible length of 34 cm. or more.

Horizon.—Cenomanian to Senonian.

Locality.—South-East England generally, so far as recorded.

Lectoholotype.—B.M. 4152, ex Coll. G. A. Mantell.

This appears from the British Museum specimens to be common in the Cenomanian zone of *Holaster subglobosus*, and the nature of their matrix suggests that Mantell's figured specimens probably came from this zone. He gives as localities "Upper and Lower Chalk, near Lewes and Brighton" (*Foss. S. Downs*, p. 233). The matrix of the figured specimens suggests Lewes rather than Brighton. Since Mantell says (loc. cit.) that his "Tab. xl, fig. 2, represents the usual appearance of these fossils", I fix on the original of that figure (B.M. 4152) as lectoholotype. Mantell says that specimens "occur abundantly in the Upper chalk, and occasionally in the siliceous nodules". All these may have been formed by the same species; one cannot distinguish them.

In addition to a number of specimens labelled "Kent" or "Sussex", or merely "S.E. England", there are in the British Museum representatives of this typical form from the following more precise localities:—

Folkestone. Chalk Marl, Cenomanian. [58255.]
Hamsey, Sussex. "Grey Chalk Marl," Cenomanian. [4154.]
Cowslip Pit, near Guildford. Cenomanian. [A 1571/2/3.]
Burwell, Cambridgeshire. Greyish "Lower Chalk", Cenomanian. [58256.]
Aylesford, Kent. Cenomanian (?). [23158.]
Near Lewes. "Lower Chalk," Cenomanian. [4124, 4148, 4151, 4152, 25942 (?).]
Near Lewes. "Upper Chalk." [4122, 4156, 58259, A 73.]
Davis' Shalford Pit, near Guildford. Upper Chalk, Senonian. [A 1627–A 1634.]
St. Giles' Gates, near Guildford. "Upper Chalk." [58258.]
Chatham. "Upper Chalk." [A 1636.]

It will be noted that the Turonian is, so far as our definite information goes, unrepresented in this list. In March, 1880, however, I obtained a specimen from the *Terebratulina* zone near Winchester, duly exhibited before the College Natural History Society as 'a fossil fish'. Mr. T. H. Withers tells me that in Oxfordshire and Surrey the species is common in that zone, as also in the *Rhynchonella Cuvieri* zone of Surrey.

Although this fossil is not noticed by name in his papers on the Chalk, Dr. A. W. Rowe kindly permits me to give as his experience that it occurs in every zone of the White Chalk. It is, he says, rare in the zones of *Belemnitella mucronata* and *Rhynchonella Cuvieri*, but especially common in those of *Marsupites* and *Micraster cor-anguinum*; it is also common at Dover in the zones of *M. cor-testudinarium* and *Holaster planus*.

That these bodies were tubular was maintained by Davies, on the evidence of specimens, not more precisely designated, in the British Museum. Apparently the tubes have sometimes been flattened, at least in part [23158]. Frequently they have an elliptical section, probably due to post-mortem compression; thus we find diameters of 18 and 12 mm. [A 1627], of 20 and 14 mm. [25876], of 22 and 15 mm. [58262]. But that the tubes had a moderate amount of rigidity may be inferred partly from the fact that the specimen last mentioned has a core of flint, partly from specimen A 1629, in which a *Spondylus* valve lying alongside has been broken by pressure against the tube.

Considerable variations in the apparent diameter of the tube (e.g. 30 and 20 mm. [A 1632], 20 and 13 mm. [25943]) are probably due to crushing; and this cause may also account for the appearance of a short branch about the middle of the length (16 cm.) preserved in A 1573, where the width at one end is 21 mm. but close to the branch only 12 mm. There is a similar appearance in A 1567, made of conifer leaflets.

The maximum length of these tubes was given by Mantell as 2 feet, but Davies maintained that they might have been longer "as no specimen with the extremities entire has yet been discovered". I don't quite see how one is to decide whether an extremity is entire or not, except by knowing that a piece was left behind in the quarry, and certainly this has not been the case with all specimens. The longest specimen in the British Museum is that figured in Dixon's *Geology of Sussex*, pl. 34, fig. 5 [58261]; it is 35 cm. long (a little less than the "fourteen inches" assigned to it by Davies), and 35 mm. wide; the included fin-rays, according to Davies, "exceed two inches in length," and some are actually 10 cm. long, nearly 4 inches. The horizon and locality of this specimen are unknown. The longest specimen from the Mantell Collection [4126] is 29·5 cm. long and 20 mm. wide; it is said to be from the "Chalk, Lewes". These measurements do not follow the curves of the specimens. Davies speaks of the "comparative straightness" of the tubes, but the longer specimens, at least, are always curved and often markedly sinuous; thus, A 1629 is like an elongate *ſ*, with an approximate length of 20 cm. and a diameter of 16 mm., and shows no obvious signs of being incomplete.

The width of the tubes can rarely be measured with great exactness; as already mentioned it often varies, and is probably always exaggerated by crushing, especially in the larger specimens. In the following cases the maximum width observed is the one given. Beginning with 10 mm. (3 specimens), this maximum passes through 13 mm. (1), 14 mm. (1), 15 mm. (3), 16 mm. (3), 17 mm. (2), 18 mm. (4), 20 mm. (13), 21 mm. (1), 22 mm. (3), 23 mm. (1), 25 mm. (2), 28 mm. (1), 30 mm. (4), up to 35 mm. (4): total, 46 specimens. It will be observed that by far the largest number of specimens is associated with the width of 20 mm., and that there are 17 specimens below this and 16 above it. Making allowance for the exaggeration by crushing in the widest specimens, we infer that this width of 20 mm. is almost exactly the mean, and that the natural limits of the species are about 10 mm. and 30 mm. In the circumstances one would perhaps not expect any relation between the length of the specimens and their width; certainly no such relation is perceptible. Neither is there any relation between the width of the specimens and the horizon from which they come.

A specimen from the Gault, though also composed of fish-remains, differs from all the Chalk specimens in its markedly greater width. Since there is no reason for regarding this as due to exceptional crushing or any peculiar conditions of preservation, and since it is improbable that a species living in Gault mud continued unchanged into the Chalk ooze, it seems advisable to establish a new species—

'*Terebella*' *lutensis*[1], n.sp.

Diagnosis.—Tube of fish-debris, with diameter over 4 cm. and with a possible length of 29 cm. or more.

Horizon.—Albian: Gault.

Locality.—Eastbourne, Sussex, so far as recorded.

Holotype.—Brit. Mus. A 23, ex Coll. John Morris. (Plate XXIV, Fig. 6.)

The exact measurements of the holotype are 29 cm. × 4·5 cm. × 2·4 cm. The wall is thick and has a coarse appearance, due to the large size of the scales and bone-fragments and their irregular arrangement.

TUBES OF PLANT-DEBRIS.

Of these there are in the British Museum seven specimens. Two of them [A 1565, A 1566] from "Dorking Pit", Surrey, are probably of Cenomanian age from the zone of *Holaster subglobosus*; one [A 1640] is from the "Upper Chalk" of Broadstairs, Kent; of the others [A 1567 – A 1570] from the Chalk, probably of Sussex, the precise localities and horizons are unknown.

There can be no question but that these bodies are of the same nature as the tubes made of fish-debris, and many of the remarks concerning those are equally applicable to these specimens. None of them, however, exceeds 16 cm. in length [A 1640]. The widths range from 17 to 35 mm. Reference has already been made to A 1567, which has apparently a slight branch; the tube is 7·5 cm. long, 23 mm. wide at one end, and only 11 mm. wide beyond the apparent branch—measurements which confirm the view that the appearance is due to crushing.

[1] Dwelling in clay.

There is slight variation in the character and arrangement of the leaflets that compose these tubes. Thus in A 1568 (Fig. 8) the leaflets have a length of 20 mm. or a little less, and cross one another irregularly, but are more or less longitudinally placed; in A 1569 the leaflets are 14 mm. or less in length, and cross irregularly; in A 1570 they are about 10 mm. long, irregular, but tend to a longitudinal arrangement; in A 1640 they are 10 mm. or less in length and quite irregularly scattered; in A 1565 they are rather shorter and irregular, and are combined with fragments of bark; in A 1567 the leaflets lie somewhat longitudinally or at a rather regular angle, and there is in places an appearance as of two layers crossing; in A 1566 (Fig. 7) the leaflets are short, probably mixed with bark, and seem to imbricate irregularly.

These tubes have a rather straighter appearance than those of fish-debris; but this may be due to their less length. A slight curve is to be seen in A 1566, which is 10 cm. long. A 1640 is probably curved, but is much flattened, and its outlines are not clear.

As Dr. Stopes has kindly pointed out to me, J. Velenovský in 1885 figured fir-needles composing a similar tube in the Cretaceous Teplitz beds of Raudnic, Bohemia, and gave to them the name *Abies minor*.[1] It is not to be inferred that any of our specimens necessarily belong to the same species of worm as the tube figured by Velenovský, or that the plant-remains are identical with those described by him.

Tubes of Echinoderm-debris.

At present I know of only the one specimen previously referred to, namely A 1583 in the British Museum. This is composed of ossicles of Asteroids and Ophiurids. It comes from the Cenomanian Grey Chalk of Folkestone, Kent. Its length is 15 cm.; its width, 16 mm.

Tubes of this composition may be of more frequent occurrence than one might infer from their rarity in our collections. Assemblages of small Echinoderm ossicles do not, as a rule, appeal to the collector, unless the ossicles in themselves have some peculiar interest.

The Taxonomic Value of the Building Material.

Before proceeding to the discussion of those tubes in which no building material is obvious, we may pause to consider whether the difference of composition in the tubes already described indicates the existence of more than one species of Annelid. It may be that the worm merely seized on any appropriate fragment that chanced to lie in its neighbourhood; or it may be that divers species selected each its own peculiar objects, as is the habit of various lowly animals in modern seas.[2] Either view may be supported by the described habits of modern Terebelliformia.

The process of tube-construction in *Terebella* and its allies was observed and described by Sir J. G. Dalyell (1853, *Powers of the Creator*, vol. ii, pp. 176–205), and Mr. Arnold T. Watson has given

[1] *Die Gymnospermen der böhmischen Kreideformation*, Prag, 1885; see p. 33, pl. viii, fig. 1.

[2] e.g. *Phorus agglutinans* covers its shell with extraneous objects; one form carefully using rocks is called 'the mineralogist', another selecting small shells is called 'the conchologist': this supposed *selection* may, after all, be due to the occurrence of shells in one locality and stones in another.—Editor.

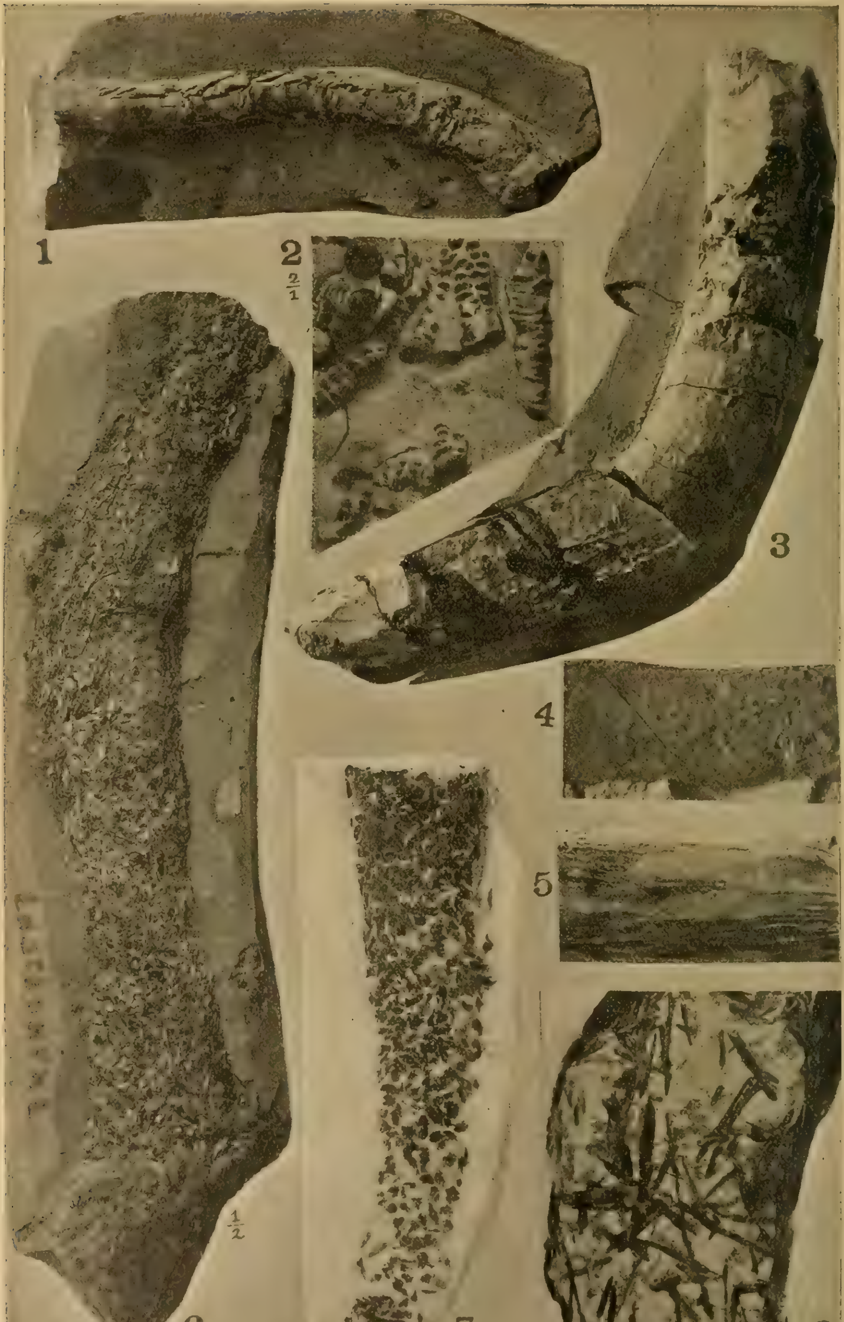
further details for a species of *Terebella* (Journ. R. Micr. Soc., 1890, pp. 685–9, pl. xiv). In January, 1894, Professor W. C. M'Intosh published a lecture "On certain Homes or Tubes formed by Annelids" (Ann. Mag. Nat. Hist., ser. vi, vol. xiii, pp. 1–18), summarizing *inter alia* the facts in his *Challenger* Report on the Annelida Polychæta (1885).

The evidence for selective faculty or habit, when presented by rare species known from only one or two localities, is of course unconvincing; but there are some fairly clear instances among species that are better known. Thus *Euthelepus setubalensis* seems to select hexactinellid sponge-spicules from the foraminiferal mud in which it lives (M'Intosh, *Challenger* Report, p. 466), and according to Dalyell (1853, p. 176), "The animals [of *Sabella alveolaria*] testify a decided preference on choosing the materials of their habitations. While always preferring sand and comminuted shell, pounded glass is sparingly and reluctantly employed, and unless for a few fragments, it is soon entirely rejected."

On the other hand, one and the same species is known to make its tube of different material according to circumstances. "Thus in *Northia* [sic] *conchylega*," says Professor M'Intosh (1894, p. 6), "the tube proper is, in the Zetlandic examples . . . strengthened externally by entire shell-valves, large fragments of the latter, pieces of sea-urchins and heart-urchins, or, in those procured by the *Knight Errant* in 608 fathoms in the Atlantic, of coarse gravel." Again, Professor M'Intosh (1894, p. 13) figures two similarly-shaped tubes of *Amphictene auricula*, one from shallow water, formed of sand-grains irregularly disposed, the other from deep-sea mud, built of sponge-spicules in regular layers. An example that has some bearing on the present case is *Nothria macrobranchiata*, M'Intosh (1885, *Challenger* Report, p. 322; and 1894, p. 6), dredged in green mud at 345 fathoms south of Yedo [Tokyo], Japan. This "utilized the long linear leaves of the pines swept down by the rivers, besides leaf-stalks and leaves, straws, stones, and fragments of echinoderms, to strengthen its tube of greyish mud". In the specimens described and figured the pine-needles were arranged longitudinally to serve as a sort of scaffold, only one or two being used.

Notwithstanding the curious mixture of materials occasionally observed, one does get the impression that the tubes are to some extent characteristic of the various species. The character, however, seems to reside as much in the size of the fragments as in their material. There are also differences in the relative amount of secretion contributed by the worm itself, and in the arrangement of the foreign particles, as well as obvious differences in the actual size of the tube.

Reverting to the Cretaceous tubes, we note that the materials, though diverse, are not mixed. There is little difference in general appearance between a tube formed of fish-debris and one of fir-leaves, but no examples contain a mixture of the two. A tube may, as Davies observed, include scales of more than one species of fish, but it includes nothing except fish-debris. Another tube consists of leaves, bits of bark, and so forth, but comprises nothing that is not vegetable. So, again, specimen A 1583 contains ossicles of both



CRETACEOUS TEREBELLOID WORM-TUBES.

Ophiurids and Asteroids, but there is nothing that is not echinodermal. One could wish for rather more definite evidence as to the precise locality and horizon of all our specimens, but it is at any rate well known that the tubes of fish-debris occur throughout the Upper Cretaceous rocks of South-East England, and one fails to see why the animals that made them should not occasionally have mixed their materials, as do their modern analogues. Here, however, we must observe that fish-scales do not appear to be in common use among modern tube-builders.

The particular materials used in each case appear to depend not merely on propinquity, but also on the ease with which the particular species can use them. The relative weight of the materials, the nature of their surface, or the differences of size may each or all affect their adaptability to the creature's mechanical powers. Whatever be the reason, certain species do, as we have seen, exercise a power of selection, and to that extent the converse holds good, namely, that tubes composed of obviously selected materials characterize diverse species.

All these considerations incline me to the conclusion that the remains of fishes, plants, and echinoderms were selected by three different species of worm. But before distinguishing these species by name, I await such confirmatory evidence as would be afforded by the occurrence of these three kinds of tube at the same level in a single limited area. Some of our enthusiastic students of the Chalk will doubtless be able to furnish the national collection with the desired material.

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

EXPLANATION OF PLATE XXIV.

FIG. 1. *Keckia* (?) sp. Probably Lower Cenomanian, South-East England. B.M. 4784.

,, 2. *Granularia* (?) sp. Albian, Gault, Folkestone. Portion of a small slab covered with similar tubes. B.M. 39453. × 2 diam.

,, 3. '*Terebella*' *cancellata*, n.sp. Cenomanian, probably *Holaster subglobosus* zone, Glynde, Sussex. Holotype. B.M. 58253.

,, 4. '*Terebella*' *cancellata*, n.sp. Probably same horizon, Cowslip Pit, near Guildford, Surrey. Portion of the infilling of a tube. The photograph shows the impressions, but does not bring out their curved arrangement; this has therefore been emphasized by a little white paint along one curve. The diagonal striation is very clear in the photograph, but is too fine to be reproduced by the half-tone process; one line has been emphasized, to show the direction. B.M. A 1577.

,, 5. '*Terebella*' *cancellata*, n.sp. Same horizon and locality. Portion of the infilling of a tube in which the longitudinal folds are strongly marked. B.M. A 1574.

,, 6. '*Terebella*' *lutensis*, n.sp. Albian, Gault, Eastbourne. B.M. A 23. × $\frac{1}{2}$.

,, 7. '*Terebella*' *lewesiensis* (?). Cenomanian, Dorking Pit, Surrey. Tube made of conifer leaflets and bits of bark, imbricating. B.M. A 1566.

,, 8. '*Terebella*' *lewesiensis* (?). Cenomanian (?), South-East England. Part of a wide tube of long conifer leaflets, irregular, but mostly longitudinal. B.M. A 1568.

All figures are natural size, except Nos. 2 and 6. All are from photographs by Mr. H. G. Herring.

II.—On some Crustacea of the Division Syncarida from the English Coal-measures.

By W. T. Calman, D.Sc.

I. *Palæocaris præcursor* (H. Woodward).

Among the Crustacea from the Coal-measures of Coseley, near Dudley, which have been lent to me for examination by Mr. Walter Egginton, are a number of specimens of a form probably identical with that described by Dr. Henry Woodward[1] as *Præanaspides præcursor*. These specimens make it possible to supplement, in some important particulars, the original account of the species, and throw fresh light on its relations to the living Syncarida. Reasons are given below for regarding the genus *Præanaspides* as a synonym of *Palæocaris*, Meek & Worthen.

Description of the Material.—The fossils are contained in nodules of clay-ironstone, and in most cases the parts of the animal are represented by cavities in the matrix, exposing the inner surface of the exoskeleton when the nodule is split open. The cavities are usually lined with a brownish film, probably representing the substance of the exoskeleton,

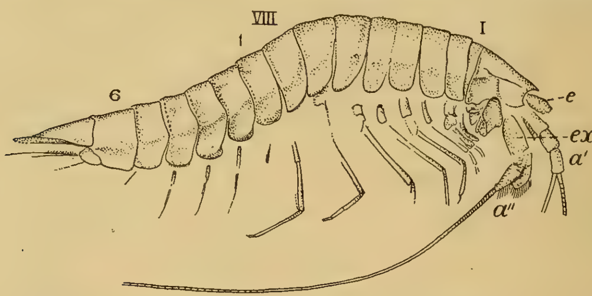


Fig. 1. *Palæocaris præcursor* (H. Woodw.). Specimen No. 8 in Mr. Egginton's collection. × 4½. *a′*. antennule; *a″*. antenna; *e*. eye-stalk; *ex*. part of exopodite or scale of antenna; I, first thoracic somite; VIII, eighth thoracic somite; 1, first abdominal somite; 6, sixth abdominal somite.

and are more or less filled in places by deposits of pyrites and of a soft white substance, probably ferrous carbonate. The cavity of the abdomen in some specimens contains an elongated cylindrical body which may perhaps represent the fossilized contents of a capacious intestine.[2]

[1] Geol. Mag., Dec. V, Vol. V, p. 385, 1908.

[2] It may be useful to give some notes on the methods that have proved most effective in the study of these fossils. A Zeiss binocular dissecting microscope was used, and the cleaning of the specimens with needles was aided by cautious applications of hydrochloric acid. The interpretation of the hollow parts is greatly facilitated by taking impressions in modelling wax, but it has to be borne in mind that these impressions of the *inner* surface of the exoskeleton do not give accurately the relief of the *outer* surface, for example, in the relation of the mandible to the side-plate of the head, as shown in Fig. 2, A. In some cases the parts of the fossil (e.g. the thoracic exopodites) are distinguished from the matrix by a difference of colour, not of relief. These are seen most clearly if the surface be wetted and a thin cover-glass placed on it.

In the most complete specimen (Fig. 1) the body, of which the side view is exposed, is about 16 mm. in length, and is curved so that the dorsal edge is convex in the thorax and concave in the abdomen. Eight thoracic somites are visible behind the head, followed by six abdominal somites and the telson.

The *head* (Fig. 2, A) is about 1·8 mm. in length and the same in depth at the hinder edge. It is produced in front into a very short rostrum, beneath which the margin shows a distinct concavity no doubt representing the orbital notch. The lower margin appears to overlap the bases of the mouth-parts as a pleural fold, although this cannot be clearly seen on the internal aspect as exposed in the fossils. On the side of the head a very distinct groove (represented by a ridge on the inner surface) runs vertically upwards from the basal angle of the mandible, but dies out before reaching the dorsal surface. A horizontal groove, starting from the hind margin at about the middle of its height, runs forwards for a short distance, but does not reach the vertical groove. In the specimen represented in Fig. 1

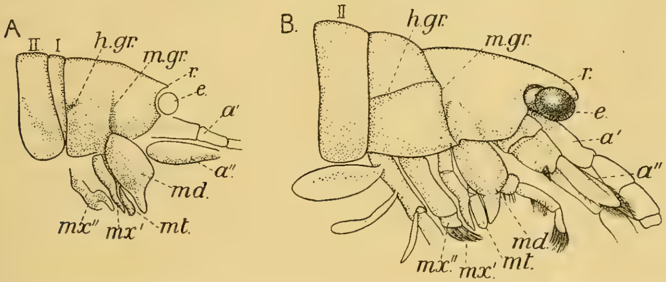


FIG. 2. Lateral aspect of head-region. A. *Palæocaris præcursor.* Drawn from a wax impression of specimen No. 15 in Mr. Egginton's collection; the side-plate of the head would overlap the base of the mandible if the actual outer surface were seen. × 5. B. *Anaspides tasmaniæ.* × 6. *a'*. antennule; *a''*. antenna; *e*. eye; *h.gr*. horizontal groove; *md*. mandible; *m.gr*. mandibular groove; *mt*. metastoma; *mx'*. maxillula; *mx''*. maxilla; *r*. rostrum; I, first thoracic somite; II, second thoracic somite.

this horizontal groove is obscured by a strong fold that runs for the whole length of the head, but this is evidently due to crumpling of the exoskeleton. The vertical and horizontal grooves seen in Fig. 2, A, however, are certainly normal features and are seen in several of the specimens; their significance will be discussed below.

The *first thoracic somite* is very short, its dorsal margin being only about half as long as that of the succeeding somite. In side view it is wedge-shaped, narrowing below so that the fore edge of the second somite almost touches the head at its lower end. It is possible that the line defining the first somite from the head may indicate a suture rather than a movable articulation, for no overlapping of the edges can be observed.

The remaining thoracic somites differ in length among themselves, but owing to the varying degrees of flexion or extension of the body in the different specimens it is not easy to determine the exact relations in this respect. The fifth somite appears to be the shortest, and at all events the side-plates of this somite are distinctly narrower (antero-posteriorly) than those of the adjacent somites. The seventh somite appears to be the longest. On the dorsal side the second, third, fourth, and fifth somites are seen each to overlap the somite in front, while the sixth, seventh, and eighth, like those of the abdomen, overlap backwards. It is probable that the fifth somite overlaps both in front and behind, but this cannot be distinctly seen.[1] In one other respect also the fifth somite divides the thorax into two regions, for the second, third, and fourth somites have the lower margin of the side-plates rounded with a slight obliquity forwards, while those of the sixth, seventh, and eighth are pointed and directed backwards. The lower margins do not seem to overhang the bases of the legs. The depth of the thoracic somites is about 2 mm.

The *abdomen*, excluding the telson, is a little shorter than the thorax. The first five somites do not differ greatly in size, the length of each being a little less than that of the posterior thoracic somites. The pleural plates are rounded and slightly produced backwards. The sixth somite is a little more than half as long again as the fifth and of equal depth anteriorly, narrowing a little posteriorly.

The *telson* is not well displayed in any of the specimens. It is shorter than the uropods, broadly rounded at the tip, and fringed with spines. Its great apparent thickness at the base in side view may be due to crushing.

Appendages.—In several of the fossils a very distinct impression is seen in front of the head above the base of the antennule. There can be little doubt that this represents the *eye-stalk*, although the form of its distal end is not clearly defined in any of the specimens. It tapers slightly towards the base and appears to have been at least twice as long as its greatest diameter.

The *antennule* has the three segments of the peduncle successively diminishing in thickness; the first is the longest and the second the shortest. The flagella are incomplete in the specimen figured, but another specimen shows both of them to be at least twice as long as the peduncle.

The *antenna* shows distinct traces of a large lamellar exopodite, but in no case can its complete outline be traced. The last segment of the peduncle appears to bear a prominent lobe fringed with setæ, but it is possible that this is really the tip of the overlying exopodite. The flagellum is about as long as the body; its segmentation is very distinct in some specimens, the segments being broader than long and slightly oblique near the proximal end and becoming longer than broad towards the tip.

Impressions of the *mandibles* (Fig 2, A) can be seen in many of the fossils. The 'body' of the mandible is large and its obtusely pointed proximal end is overlapped by the side-plate of the head; distally it is produced into a narrow incisor process, and it forms on the anterior margin a marked shoulder where the palp may have been articulated.

[1] In *Anaspides* the fourth thoracic (third free) somite overlaps both in front and behind. I have not been able to determine the overlap of the somites in the other recent genera.

Traces of other mouth-parts are seen in some of the specimens, and in one (Fig. 2, A) they resemble so closely the mouth-parts of *Anaspides* (Fig. 2, B) as seen from the side that there can be little hesitation in identifying the *metastoma* (lower lip), *maxillula*, and *maxilla*.

The eight pairs of *thoracic limbs* all appear to be slender in the specimens examined. Those of the first pair are only obscurely seen and appear to be very short; the others successively increase in length. The apparent slenderness of these limbs in comparison with those of the type-specimens of *P. præcursor* will be discussed later.

Several specimens show traces of *exopodites* on the thoracic limbs, and they are very clearly seen in the specimen figured (Fig. 3). They are flattened and lanceolate in outline, about 1·5 mm. in length, and ·2 mm. across the widest part. Each is divided into a number of short segments, which are broader than long except towards the tip. No traces of marginal setæ are preserved. No exopodite can be seen on the last thoracic leg, and it is probable that this limb was devoid of an exopodite as it is in the living Anaspidacea.

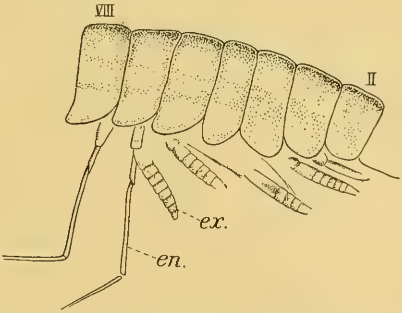


FIG. 3. *Palæocaris præcursor.* Portion of thoracic region showing legs and exopodites. From specimen No. 19 in Mr. Egginton's collection. × 6. *en.* endopodite; *ex.* exopodite; II, second thoracic somite; VIII, eighth thoracic somite.

The remains of the *pleopods* are somewhat obscure. The *uropods* are not well displayed in any of the fossils, but, as far as can be seen, they agree with the original description of *P. præcursor*.

Comparison with Præanaspides præcursor.—The specimens described above agree closely with the original account of *P. præcursor* in the form and segmentation of the body, and in the general structure of the appendages as far as these are available for comparison. They differ in their generally smaller size, the absence or obscurity of the transverse striation of the somites, the wedge-like outline of the first thoracic somite as seen from the side, and the greater slenderness of the thoracic limbs. As regards the first of these points, none of the specimens now examined can have much exceeded 16 mm. in length, while one of the co-types of the species reached a length of 57 mm. Dr. Woodward, however, mentions specimens of 15 mm. and even 10 mm. in length. The absence of striation on the somites may not improbably be due to a difference in the condition of preservation.

The first thoracic somite is described and figured by Dr. Woodward as parallel-sided in lateral view, but a slight depression of the head might probably produce the wedge-like outline seen in the specimens figured above, the first somite being overlapped by the side-plates of the second somite.

The difference in the form of the legs is much more likely to be significant. In one of the co-types of the species, that represented in Fig. 3 on p. 386 of Dr. Woodward's paper, and now in the British Museum collection, the endopodite of the penultimate leg is well displayed, and the large segment on the proximal side of the 'knee' (probably the merus) is less than four times as long as broad. In a specimen in Mr. Egginton's collection, represented in Fig. 3 above, the corresponding segment of the penultimate leg appears as if it were at least ten times as long as broad. A careful examination of both specimens, however, does not convince me that they are exactly comparable in this respect. The apparent broadening of the limb in the one case may be somewhat exaggerated by compression, while, on the other hand, a flattened segment might not display its full width if it happened not to lie exactly in the plane of fracture of the matrix. I think, therefore, that the evidence is inadequate to justify the separation of the Coseley specimens as a distinct species from that described by Dr. Woodward.

Comparison with Palæocaris.—The genus *Palæocaris* was established by Meek & Worthen in 1865 [1] for a single species, *P. typus*, of which a figure was published by the same authors in 1868.[2] The species was discussed at greater length and a restoration given by Packard in 1886.[3] Other species have since been referred to the genus, but they are too imperfectly known to require further consideration here.[4]

The restoration of *Palæocaris typus* given by Packard and reproduced here (Fig. 4) agrees very closely with the original figures of *Præanaspides* as regards the segmentation of the body. It differs chiefly in the form of the thoracic legs, of which six pairs are shown, having the endopodites very slender and the exopodites broad, flattened, and each divided into three segments. For the reasons given above I cannot regard the apparent slenderness of the endopodites as important, and it may be significant that in Meek & Worthen's original figure the legs are represented as much stouter than in Packard's restoration. In this character and in the form of the exopodites the Coseley specimens described above agree remarkably well with Packard's figures, the only important divergence being that the segments of the exopodites are more numerous. This, however, is a point on which it is very easy to be misled, and it is not unlikely that Packard may have overlooked some of the delicate lines of articulation. The greater

[1] Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 48.

[2] Geol. Surv. Illinois, iii, p. 552.

[3] Mem. Nat. Acad. Sci. Washington, iii (2); Mem. 15, pp. 129–33, pl. iii.

[4] It is possible that *Palæocaris Burnettii*, H. Woodward (Geol. Mag., Dec. II, Vol. VIII, 1881, p. 533, Pl. XIV, Figs. 3*a*, *b*), might prove to be identical with the species discussed here, but the specimen from which it was described is probably too imperfect to make sure of this.

relative length of the sixth abdominal somite in the American specimens seems to be almost the only difference available for their specific separation from the English form, and it is possible that even this might not survive a re-examination of the fossils. At all events it seems clear that the two forms cannot be generically separated, and I propose to regard *Præanaspides* as a synonym of *Palæocaris*.

Comparison with recent Syncarida.—A comparison of the head-region of *Palæocaris* as described above with that of the recent Syncarida (see Fig. 2) leads to some important conclusions. There is hardly room for doubt that the groove running upwards from the base of the mandible on the side of the head corresponds to the so-called 'cervical groove' of *Anaspides* (Fig. 2, B) and *Paranaspides*, and the fact that it dies out before reaching the dorsal surface is paralleled in *Koonunga*. The horizontal groove behind it has exactly the same relations as the similar groove found in *Anaspides* and *Paranaspides*, though it does not extend so far forward as in these genera.

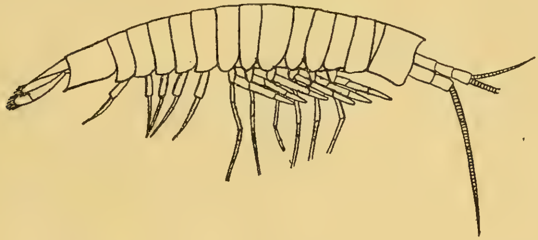


FIG. 4. *Palæocaris typus*. Restoration. After Packard.

I formerly suggested[1] that the 'cervical groove' of *Anaspides*, which had been regarded as defining the first thoracic somite from the head, should rather be identified with the 'cervical sulcus' which, in the Mysidacea, crosses the carapace immediately above the mandibles. Later[2] I expressed some doubt as to this interpretation, but it is very strongly supported by the evidence of the fossils now described. The narrow and generally wedge-shaped segment behind the head in *Palæocaris* must undoubtedly be regarded as the first thoracic somite, and there is nothing visible in the living Syncarida which can be compared with it. The term 'mandibular groove' may conveniently be applied in all these cases to the groove running upwards from the attachment of the mandible.

The confirmation now afforded of previous statements as to the existence of pedunculated eyes and of thoracic exopodites in the fossil Syncarida goes to strengthen the case for their association with the living Anaspidacea. Almost the only conspicuous structural feature of the latter that has not been recognized in the former is the series of lamellar gills on the thoracic legs. From the delicacy of their texture it is hardly likely that these would be preserved, but it is not beyond possibility that traces of them may yet be discovered.

[1] Trans. Roy. Soc. Edinb., xxxviii, p. 787, 1896.
[2] Ann. Mag. Nat. Hist. (7), xiii, p. 155, 1904.

II. Further Note on *Pleurocaris annulatus.*

Since the publication of my paper on this species[1] I have been able to examine a very successful impression taken from one of the British Museum paratypes (I 13814) by Mr. T. H. Withers, and showing some features that were overlooked in the examination of the fossil itself. The most important of these relate to the upper surface of the head (Fig. 5), which was not displayed in any of the other specimens examined.

The anterior margin of the head is produced into a short, bluntly pointed rostrum. On each side of this is an impression that most probably represents the basal segment of the antennule, although it is not impossible that it may be an eye-stalk. The head-region is divided by a strongly-marked transverse groove into two portions, of which the posterior is wider than the anterior, and more than half its length measured to the tip of the rostrum. On each side of the posterior division is a swollen area marked off by a groove, which has an oblique and sinuous course from the antero-lateral corner to the posterior margin, which it reaches at a little distance from the middle line.

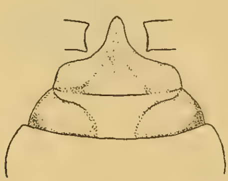


Fig. 5. *Pleurocaris annulatus.* Restoration of dorsal surface of head-region, based on an impression taken from one of the paratypes (I. 13814) in the British Museum collection.

Behind the head-region just described this specimen shows very clearly that there are only *seven* free thoracic somites, all of them provided with expanded pleural plates. It is therefore possible that the posterior division of the head-region, marked off by the transverse groove, may represent the first thoracic somite. On the other hand, the groove seems to lie just about the region of the mandibles, and well in front of the position where the anterior limit of the first thoracic somite might be expected. It seems much more probable, therefore, that it is to be identified with the 'mandibular groove' described above in *Palæocaris.* If this be so the groove defining the swollen area on each side may very well represent the 'horizontal groove' of *Palæocaris* and *Anaspides.*

Apart from the morphological interpretation of the parts, however, the dorsal aspect of the head-region presents a very close similarity to that described and figured by Packard in *Acanthotelson.*[2] In both cases the head-region is divided by a transverse groove into two parts, of which the posterior is the longer and the anterior is provided with a short rostrum; in both cases also the posterior division has on each

[1] Geol. Mag., Dec. V, Vol. VIII, p. 156, 1911.

[2] Mem. Nat. Acad. Sci. Washington, iii (2); Mem. 15, p. 124, pl. i, fig. 1*a*, 1886.

side 'a low boss-like swelling situated obliquely'. The agreement is sufficiently close to put beyond doubt the affinity, already suggested, between *Pleurocaris* and *Acanthotelson*.

I am indebted to Dr. Henry Woodward for calling my attention to an additional specimen of *Pleurocaris* in the British Museum collection (I 14449) from the same locality as the type-specimens. It differs from these, not only in its larger size (the total length when complete cannot have been much less than 30 mm.), but also in being relatively much wider, measuring 10 mm. across the widest part. This increase in width is due to the greater size of the thoracic pleural plates, which extend on each side for a distance nearly equal, in the middle of the thorax, to the transverse diameter of the somites themselves. It is probable that the increased size of the pleural plates is merely a character of maturity or of age, and that it does not indicate a distinct species.

III.—The Culm-measures of the Exeter District.

By E. A. Newell Arber, M.A., F.G.S., Trinity College, Cambridge.

In the interesting paper, by Mr. F. G. Collins, on the so-called Culm-measures of the Exeter district, which has recently appeared in the last number of the Quarterly Journal,[1] there are to be found certain conclusions which can hardly pass unchallenged. When this paper was read at the Geological Society, I happened to be in the extreme west of Ireland, and thus, unfortunately, I was unable to be present at that meeting or to take part in the discussion. In fact, it was not until my return to Cambridge in September that I knew anything of the substance of the paper, beyond the very small contribution on the fossil plants which I wrote for it some time ago.

The chief value of this paper lies in the records of the Carboniferous fauna from South Devon. I must, however, take exception to the author's chief conclusions.[2] Mr. Collins remarks that "comparing the list of South Devon forms with that of the fauna of the 'Pendleside Series' and that of the Carboniferous Limestone as tabulated above, we cannot fail to be impressed with the great resemblance of this fauna to that of the 'Pendleside Series'". Also that "the fossils, however, described in the present note, support for South Devon what Dr. Hind has stated to be the case in North Devon, namely, that the Lower Culm-measures are the homotaxial equivalents of the 'Pendleside Series' of the Midlands". Whether or not the scanty flora mentioned in the paper is intended to be included in these conclusions is not self-evident, but I wish to take the opportunity of pointing out that the rocks from which the few fragmentary plant remains there recorded were obtained, are beyond question of Upper Carboniferous age.

It is quite clear that, both as regards the plants and the fauna, Mr. Collins has failed to recognize the important fact that rocks belonging to both the Upper and Lower Carboniferous series occur

[1] Quart. Journ. Geol. Soc., vol. lxvii, pt. iii, p. 393, 1911.
[2] Ibid., pp. 411, 413.

in the neighbourhood of Exeter. He treats the whole flora and fauna as if it belonged to one division of the stratigraphical series, whereas the specimens from some localities are of Lower, and those from others of Upper Carboniferous age. I imagine that if the author had collected fossils around May Hill, in Gloucestershire, where there is a series of sediments ranging from the Silurian to the Jurassic and including the Carboniferous, he would have paid some attention to the stratigraphy of the area, and would not have treated the whole of his collection as if it belonged to one formation or a particular subdivision of a single formation, as he has done in this case.

In this connexion it may be well to point out once again that before 1840 Sedgwick & Murchison [1] had realized that both the Lower and Upper Carboniferous formations are represented in the Devonshire syncline. The rocks belonging to the Lower series they called the Lower Culm-measures, those to the Upper, the Upper Culm-measures. I have also adopted this twofold division in my papers on the Culm-measures of North and West Devon,[2] though, as I then pointed out, the term Culm-measures is misleading and unnecessary, and is therefore best dropped.[3]

The Lower Carboniferous rocks (Lower Culm-measures) of Devonshire are quite distinct lithologically from those belonging to the Upper Carboniferous, and where a clear section exists there should be little possibility of mistaking the one for the other. I am not acquainted with the Culm-measures near Exeter in the south-east corner of the basin in detail, but in the south-west corner in North Cornwall I have studied them carefully, and they will be found described in my *Coast Scenery of North Devon*, recently published. There the lithological differences between the Upper and Lower Culm-measures are certainly marked. But I may point out that it has been known for many years past that both Lower and Upper Culm-measures occur around Exeter. Lower Culm-measures are indicated to the west and south-west of Exeter on the sketch-map accompanying Messrs. Hinde & Fox's well-known paper on the Radiolarian rocks of Devon.[4] The relations of the Lower to the Upper Culm-measures in this district are also shown very clearly in the admirable map accompanying Mr. Ussher's paper [5] on the Culm-measure types of Great Britain, published in 1901. It is true that in the revised Survey map (Sheets 325 and 339) of the Exeter district the two series are not distinguished from one another, but in the accompanying memoir Mr. Ussher [6] has clearly discriminated between them.

[1] Sedgwick & Murchison, Trans. Geol. Soc., ser. II, vol. v, pp. 682, 684, 1840.

[2] Arber, Phil. Trans. Roy. Soc. London, ser. B, vol. cxcvii, p. 291, 1904.

[3] The term 'Culm', as used by Mr. Collins in the title of his paper, is even more objectionable. It is an old West of England word for the slack of an anthracitic coal. As used by geologists, it is apparently a translation of the German 'Kulm', which itself originated on the Continent under a misconception of the nature of the Culm-measures of Sedgwick & Murchison in Devon and Cornwall.

[4] Hinde & Fox, Quart. Journ. Geol. Soc., vol. li, p. 609, pl. xxiii, 1895.

[5] Ussher, Trans. Inst. Min. Engineers, vol. xx, p. 360, pl. xvi, 1901.

[6] Ussher, *The Geology of the Country around Exeter* (Mem. Geol. Surv.), ch. ii, 1902.

Some of the localities from which Mr. Collins has obtained fossils, especially those of Canonteign, Popehouse Close, and Doddiscombsleigh, are situated on the well-known patch of Lower Carboniferous rocks, stretching from the north-east corner of Dartmoor to and beyond the valley of the Teign. Others, including all those from which plants were obtained, consist of rocks of Upper Culm-measure, i.e. Upper Carboniferous age.

With regard to the Lower Carboniferous rocks and their fauna, whether in North or South Devon, I have no remarks to make. These beds may be the equivalents of the Pendleside Series, as Dr. Hind has urged. On this conclusion I offer no comment. I have not paid particular attention to the fauna of these rocks, and I make no claim to the special knowledge of Carboniferous invertebrates necessary to enable one to enter into this discussion.

In regard, however, to the rocks at Clyst Hydon, Westwood Church, Pinhoe, and Perridge, which have yielded plant-remains, there can be no hesitation in believing them to be of Upper Carboniferous age, and they have been mapped as such by Mr. Ussher. They are what I regard as Upper Culm-measures, but which Mr. Ussher has mapped as Middle Culm-measures.[1] To which division of the Coal-measures they should be assigned remains uncertain, for the flora is too fragmentary to permit of any conclusion as to the horizon. With regard to the localities from which some of the mollusca, other than the Lower Carboniferous species already discussed, have been obtained, I strongly suspect that they also are of Upper Carboniferous age, but here again I must leave it to those who are more competent than I am in such matters to confirm or refute Mr. Collins' conclusions on this point. I wish, however, particularly to emphasize the view that, while Mr. Collins' conclusion that the rocks from which mollusca have been obtained around Exeter are the equivalents of the Pendleside Series of the Midlands may hold in so far as some at least of the localities are concerned, it certainly does not hold in regard to those which have yielded Upper Carboniferous floras, scanty though they be, in areas which no one has hitherto suspected of being other than of Coal-measure age.

IV.—On some Arthropod Remains from the Nottinghamshire and Derbyshire Coal-field.[2]

By Lewis Moysey, B.A., M.B., F.G.S.

As several rare and interesting fossils from this coal-field have been described in this Magazine[3] and elsewhere,[4] it seems advisable to place on record several other animal remains from the same district

[1] I have, for reasons stated in my previous papers on Devonshire, adopted the twofold classification of the Culm-measures initiated by Sedgwick & Murchison, in preference to the threefold scheme of Mr. Ussher, whose 'Middle' and 'Upper' are included in my Upper Culm-measures.

[2] Read in part before Section C, British Association, Sheffield Meeting, 1910.

[3] H. Woodward, *Eurypterus Moyseyi*, Geol. Mag., Dec. V, Vol. IV, pp. 277–82, Pl. XIII, 1907; also *Præanaspides præcursor*, Geol. Mag., Dec. V, Vol. V, pp. 385–96, text-figure, 1908.

[4] R. I. Pocock, Monograph Carboniferous Arachnida: Proc. Palæont. Soc., vol. lxiv, pp. 1–84, pl. iii, 1911.

which, owing to their minuteness, or to the fact that they are fragmentary, are not worthy of a separate and detailed description, in the hope that their publication may inspire geologists to obtain better and more perfect examples from other localities.

The sources from which the following specimens were obtained are:—Horizon, Top Hard Coal: Shipley Clay-pit, Derbyshire; Brinsley Clay-pit, near Eastwood, Nottinghamshire; Digby Clay-pit, Kimberley, Notts. Horizon between Waterloo and Ell Coals: Newthorpe Clay-pit, Eastwood, Notts. Horizon, roof of Kilburn Coal: Trowell Colliery refuse heap, Notts.

Fig. 1, *Leaia trigonioides*, sp. nov. Several of these minute bodies, about 3 mm. long, were discovered scattered throughout the substance of an ironstone nodule from Shipley. They were for the most part fragmentary, but two, one perfect and the other almost perfect but crushed, have been selected for description. They represent the right and left valves of what may be taken to be the carapace of a Phyllopod.

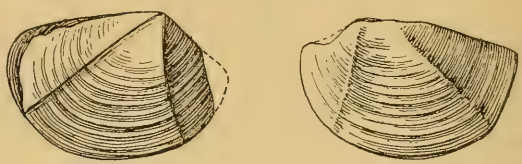


Fig. 1. *Leaia trigonioides*, sp. nov. Right and left valves of carapace. Coal-measures: Shipley, near Ilkeston, Derbyshire. Nine times nat. size.

The umbo is tumid, and is situated at the junction of the anterior and middle third of the total length of the carapace. The hinge-line or dorsal border is straight and terminates at the umbo. The anterior border runs downwards and forwards, making a rounded angle where it meets the semicircular ventral border, which latter extends posteriorly to meet the dorsal border in a more or less sharp angle. The surface of the carapace is ornamented by two well-marked curved ridges, radiating from the umbo; one downwards and forwards, the other downwards and backwards. These ridges die out before reaching the margin of the valve, thus leaving a smooth flattened ventral border. The surface is also ornamented with about nine concentric riblets, with smooth bands between, which are best seen in the median area of the valve.

A somewhat similar fossil was described by Lea[1] from Pennsylvania under the name of *Cypricardia leidyi*. Professor T. Rupert Jones,[2] in his monograph on the Phyllopods, gave it the name of *Leaia leidyi*, and described two varieties, one *Leaia leidyi*, var. *williamsoniana*, from Ardwick near Manchester, and the other *Leaia leidyi*, var. *salteriana*, from Cottage Row, Crail, Fifeshire. The present example agrees fairly closely with the Fifeshire specimen; but, on the whole, it seems best to create a new species for it, *Leaia trigonioides*, rather than risk confusion by adding a varietal appellation.

Fig. 2, *Prestwichia* sp. This is mainly of interest owing to the great difficulty of its interpretation, and was found at Shipley. It

[1] Proc. Acad. Nat. Sci. Philadelphia, vol. vii, p. 341, pl. iv, 1855.

[2] Mon. Palæont. Soc., Appendix, p. 115, pl. i, figs. 21*a*, *c*, 1862.

is bilaterally symmetrical, and consists of two broad alæ, which are divided up into irregular, more or less concentric areas, by three ill-defined radiating ridges. They are separated from one another by a well-marked median ridge which at one end divides into a deep V. A broad transverse ridge divides the expanded alæ from the other portion of the fossil, which consists of two concave elongated areas, which terminate in a couple of short blunt spines. There are also to be seen on each side the median ridge a pair of semi-lunar dots with their concavity directed towards the median line.

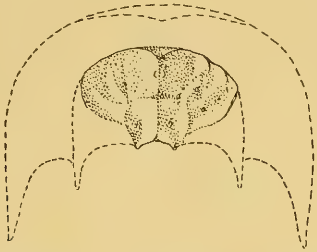


FIG. 2. ? Glabellar region of *Prestwichia*. Coal-measures: Shipley, near Ilkeston, Derbyshire. Nat. size.

This puzzling specimen is capable of various interpretations; possibly the best is that it is the glabellar region of a *Prestwichia*. The presence of the pair of dots, one on each side the median line, is in favour of this theory, on the assumption that they are the larval eyes of the animal.

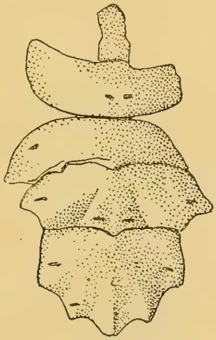


FIG. 3. Terminal segments of air-breathing Arthropod. Kilburn Coal: Trowell Colliery, Notts. Twice nat. size.

Fig. 3, Air-breathing Arthropod, indet. A small fragmentary fossil found in a nodule from the roof shale of the Kilburn Coal, Trowell Colliery, is also very puzzling. It shows what appears to be the terminal moiety of a segmented animal, with thick and possibly calcareous integument.

The ultimate segment is perfect, and consists of a shield-shaped plate about $1\frac{1}{2}$ times as broad as long; convex from side to side and also from before backwards. Its postero-lateral border is deeply emarginate, and its posterior border is prolonged backwards in the median line. The penultimate segment is fairly perfect, about three times as broad as long.

The ante-penultimate segment overrides the penultimate owing to the crushing of the fossil, and is very imperfect, its anterior border being chipped off. It appears, however, to have been similar to the penultimate segment.

The succeeding segment is very crushed, and overrides the last described, and is so intimately confused with the fragments of succeeding segments that it is impossible to make much out of it.

On the ultimate segment, in the median line, and half-way between the anterior and posterior border, occurs a minute circular pore, which may doubtfully be referred to the anal orifice, but is so minute that it could well be the opening of an odoriferous gland, similar to those found on the side of the body of modern Myriapods. The chief point of interest, however, in this specimen, is a double row of transversely placed, crescentic openings, somewhat raised from the general surface, and with tumid margins, which occur on each segment. One row is placed far out towards the lateral margin and the other on each side the median line. These openings are so similar in appearance to the respiratory stigmata found in scorpions and other Arachnids, that we may safely conclude that they had a similar function.

If correctly interpreted, the presence of stigmata and the doubtful anal orifice make it certain that we are here dealing with the posterior ventral plates of an air-breathing Arthropod, although their curvature and appearance of overlapping give the impression that they are the dorsal plates. The presence, however, of two pairs of stigmata on each segment is peculiar, and it is difficult to correlate this specimen with any living or fossil form.

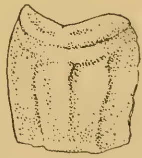


FIG. 4. Post-abdominal segment of Scorpion. Coal-measures: Shipley, near Ilkeston, Derbyshire. One and a half nat. size.

Fig. 4, Segment of body of a Scorpion. This is probably one of the post-abdominal segments of one of the scorpions, and is of interest mainly because the remains of scorpions are extremely rare. Two other examples, more perfect than this, have been obtained from this coal-field, one described by Dr. H. Woodward,[1] from the neighbourhood of Chesterfield, and another found by myself from the Digby Clay-pit, Kimberley, Nottinghamshire, and described as *Eobuthus holti* by Mr. R. I. Pocock.[2] The present example occurs in a rounded ironstone nodule. Its anterior part consists

[1] H. Woodward, GEOL. MAG., 1875, p. 622.
[2] R. I. Pocock, loc. cit. supra.

of a projecting swollen ring, with a slight depression on its most prominent part, evidently forming a facet for articulation with the next anterior segment. Behind this ring is a deep sulcus separating the anterior from the posterior portion of the fossil. The latter portion is quadrate, slightly broader than long, somewhat convex from side to side, and gradually narrowing posteriorly. Its posterior border is straight. It shows a distinct median ridge, extending only half the length of the segment, and two lateral ridges which extend fully to the posterior border. Anteriorly the lateral ridges are connected with the median one by transverse ridges, which form the posterior boundary of the above-mentioned sulcus. The specimen measures 10·5 mm. long by 9 mm. broad. It is in all probability the first segment of the post-abdomen, the articulatory facet being the point of attachment with the last segment of the præabdomen.

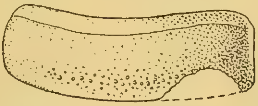


FIG. 5. Abdominal segment of *Eurypterus*. Coal-measures: Brinsley, near Eastwood, Notts. Twice nat. size.

Fig. 5, Segment of a *Eurypterus*. This detached segment of an Arthropod was found at Brinsley Clay-pits, in a small ovoid ironstone nodule. It measures 17·5 mm. broad by 6 mm. long. Its anterior border is slightly concave, and there is a line running parallel with the anterior border, and curving round to run also parallel with the lateral border, which marks off a space about 1·5 mm. wide, which is smooth. The rest of the surface of the segment is slightly roughened, but posteriorly, and laterally the roughening is exaggerated into well-marked, irregularly distributed tuberosities.

It is impossible from a single segment to allocate this Arthropod to its proper genus; but, provisionally, we may place it among the Eurypterids. It has not, it is true, the scale-like ornamentation usual to *Eurypterus*, but in the narrow abdominal segments of *E. moyseyi* the scale-like ornament is found to degenerate into tuberosities, and from its size the segment under discussion is probably one of these posterior segments.

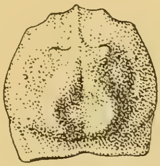


FIG. 6. Carapace of *Anthracosiro*. Coal-measures: Shipley, near Ilkeston, Derbyshire. Three times nat. size.

Fig. 6, Head of an *Anthracosiro*. It is apparently very unusual, at any rate in England, to obtain a specimen of the *Anthracomarti* which shows either the head or the appendages in a perfect condition. One specimen, however, from Shipley shows the dorsal aspect of a carapace which is not only perfect but uncrushed. Unfortunately it is quite detached and isolated, hence it is impossible with any scientific accuracy to ascribe it to any definite genus. Luckily, however, another carapace was discovered in another ironstone nodule, somewhat weathered and broken, but still capable of being compared with the perfect example, with which it was found to agree so closely that there can be little doubt as to their identity. Later, by careful development, it was found that the weathered carapace or prosoma was still attached to the opisthosoma of an Arachnid which can in all probability be referred to *Anthracosiro*.

The undamaged carapace is markedly dome-shaped, curving gradually anteriorly, while it falls rapidly posteriorly, leaving a flat central area between the domed portion and the straight posterior border. The anterior border is marked by two lateral rounded indentations, with slight-pointed prominences between, and an equally small central prominence or rostrum; the sides are rounded.

There is a faint median ridge running over the anterior half of the carapace, converted in the posterior half into a well-marked more or less stellate depression, with well-rounded lips, and occupying mainly the sharp downward posterior curve of the dome so that the depression looks upwards and backwards.

There is distinct evidence of a pair of protruding eyes, one on each side of the faintly marked median ridge, about 2·5 mm. apart, and placed on a transverse ridge running just in front of the stellate depression.

There are also to be noted several folds starting from the posterior part of the stellate depression and running round towards the sides. These, however, may be due to crushing. The whole surface is ornamented with very minute tubercles which are more pronounced in the posterior portion.

Dimensions: antero-posteriorly 6 mm., transversely 6·75 mm.

Another isolated and uncompressed carapace has been obtained from the same quarry, which appears to be identical, but is much smaller.

Dimensions: antero-posteriorly 4 mm., transversely about 4 mm., one side being embedded in matrix.

Figs. 7, 8, *Anthracosiro fritschii*, Pocock. The weathered carapace shows well the posterior flat area, the stellate depression and an eye on the left side, the rest of the anterior portion of the carapace being destroyed. Some of the appendages are also present. The limb emerging from beneath the carapace on the right side is probably one of the fourth pair of appendages, that is of the second legs. It consists of a short, distally dilated trochanter about ·75 mm. long, articulating distally with the long stout femur about 3·25 mm. in length, which runs directly out from the long axis of the body; running forward and at right angles to this is placed the patella, 2·5 mm. long; the next segment, the tibia, about equal in length with the patella, lies curving inwards towards the head. The next segment, the tarsus, lies in line with the last, is about the same length, but is somewhat obscured. The distal segment, the pretarsus, is not well shown. Embraced by the limb are the remains of four other appendages not shown in the Figure. The maxillæ on both sides, the chelicera and first leg on the right side all emerge from under the weathered anterior portion of the carapace.

The body or opisthosoma is well shown, consisting of eight segments. The junction between the carapace and the first segment, the first and the second, and the second and third, are straight and show well-marked ridges; the succeeding ones are not so well marked, and curve with their concavity backwards more and more sharply until the eighth segment is in the form of a horseshoe, enclosing on three sides a more or less quadrilateral plate, at the anterior part of which is placed a characteristically large anal ring in which can be detected the anal orifice.

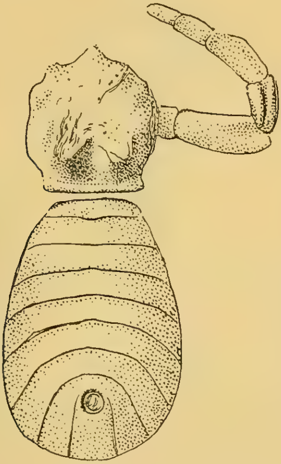


Fig. 7. *Anthracosiro fritschii*, Pocock. Showing carapace and opisthosoma, with appendage. Ventral aspect. Coal-measures: Shipley, near Ilkeston, Derbyshire. Three times nat. size.

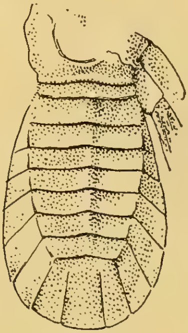


Fig. 8. *Anthracosiro fritschii*, Pocock. Dorsal view of opisthosoma. Shipley, near Ilkeston, Derbyshire. Four times nat. size.

In this case we are dealing, as in the majority of specimens found at Shipley, with the ventral aspect of the body. In two specimens from this locality, however, we have preserved the dorsal aspect of the animal (Fig. 8 *supra*). One of these gives the flat posterior area of the carapace and a small portion of the left lateral region, also the remains of two ambulatory appendages represented by their femora on the right side. The opisthosoma consists of the usual eight segments, the first being the shortest; their posterior borders all run sub-parallel to one another, the lateral laminæ marked off from the tergites by a definite line being directed more and more backwards, until those of the eighth point directly backwards, and bound on either side the quadrilateral backward extending plate of the eighth tergite.

Fig. 9, *Anthracosiro fritschii*, Pocock (dorsal aspect). The other specimen is in an ironstone nodule mixed up with a confused mass of neuropterid pinnules and other plant debris. The carapace is crushed and covers and obscures the coxæ of the appendages. On the left side the remains of four appendages are shown by their trochanters and femora; the most anterior of these is more slender than the others and possibly represents the second appendage, the posterior ones probably representing the fourth, fifth, and sixth appendages (second, third, and fourth legs). The opisthosoma is more perfect, but distorted by pressure. It shows the typical eight egments of the body. The lateral laminæ of the sixth and seventh segments alone can be made out, and there is apparently no diversional

Fig. 9. *Anthracosiro fritschii*, Pocock. Dorsal aspect. Shipley, near Ilkeston, Derbyshire. Three times nat. size.

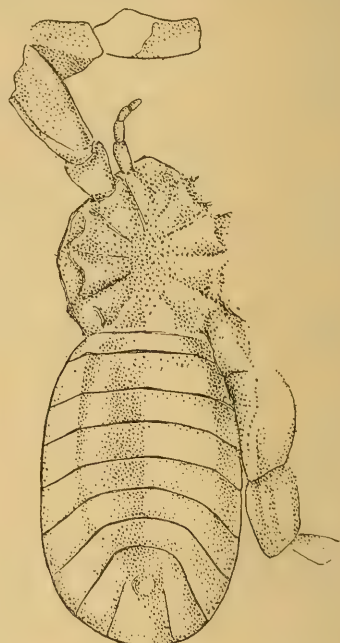


Fig. 10. *Anthracosiro woodwardi*, Pocock. Dorsal aspect, showing carapace and opisthosoma, with appendages. Shipley, Derbyshire.

line between these and their corresponding tergites. The eighth segment is very much crushed, but displays clearly through its substance the large ventrally placed circular anal orifice.

The above described specimens of *Anthracosiro*, though varying slightly in size, probably all belong to one species, and agree best with *A. fritschii*, Pocock. It would seem best, therefore, at any rate at present, to place them in that species.

Fig. 10, *Anthracosiro woodwardi*, Pocock. Another Shipley specimen is larger and more robust, and can with some certainty be referred to *Anthracosiro woodwardi*, Pocock. This specimen, though greatly obscured by a deposit of ferrous carbonate, shows a crushed carapace which covers and obscures the radiating coxæ of the appendages which are just indicated beneath it. On the right side of the head are seen the fragments of a stout femur and patella of one of the ambulatory legs, probably the first, and on the left side, running parallel to the body, is another appendage, probably the fourth walking-leg. This leg extends backwards as far as the eighth segment of the body. The opisthosoma is perfect and gives the dorsal aspect of the animal. It consists of the normal eight segments. There is no evidence of the single pair of laterally placed tubercles on each terga, mentioned by Mr. Pocock, but these are probably obscured by the quantity of white deposit which is especially marked in that region.

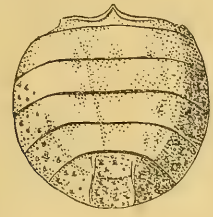


Fig. 11. Opisthosoma of an *Anthracomartus*. Dorsal view. Newthorpe, near Eastwood, Notts. Three times nat. size.

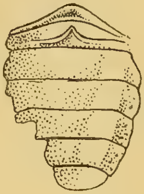


Fig. 12. Counterpart of Fig. 11, showing anterior somite.

Figs. 11, 12, *Anthracomartus*, indet. A beautiful little fossil obtained from the Newthorpe Clay-pit, Nottinghamshire, opened in the measures between the Waterloo and Ell Coals, presents the opisthosoma of an Arachnid. It shows the posterior six segments. The first segment visible on the fossil is very narrow, about one-quarter the length of the succeeding segments; its anterior border is prolonged medially into a sharp projection, hence the anterior border appears as if defined by a well-marked bracket-shaped line. This segment apparently has no lateral laminæ. The counterpart of this specimen is very imperfect (Fig. 12), but gives yet another anterior segment which is not traceable on the fossil. It consists of a very short V-shaped segment placed in an inverted position anterior to the bracket-shaped border of the other segment, and separated from it by about its own width of matrix.

The other segments are equal in length, each posterior border being parallel to the next. Owing to the fossil being uncompressed, each lateral lamina is bent over in a bold curve, thus giving to the specimen a transversely arched appearance, and they are at the same time directed slightly backwards. These laminæ are ornamented with irregularly placed, well-marked tubercles, larger towards the lateral margin. On the left side the lateral laminæ (and the ultimate segment) appear to have been removed, leaving the impression of their underside, so that the tubercles look like pits, and also demonstrating a divisional line between the terga and their respective laminæ. The rest of the segment is smooth. The ultimate segment consists of a more or less quadrate area, with its two lateral laminæ directed outwards and backwards, their posterior border being in contact with the posteriorly projecting quadrilateral plate normal to this segment in most of the Anthracomarti.

The absence, or at least imperfection, of the anterior segments makes it extremely difficult to refer this Arachnid to its proper genus. It probably belongs to the order *Anthracomartus* of Pocock, and with some hesitation we may refer it to the genus *Trigonotarbus.* It is evidently, however, a new species, and it would be, at present, best not to name it definitely, but to leave it in the hope that some experienced arachnologist may in the future be able to give it a place in the now rapidly growing list of Carboniferous spiders.

In conclusion, it would be well to describe in some detail the locality from which so many of these and other rare or new fossils have been obtained, that it ranks with the Coseley Openworks near Dudley, and the Sparth Bottoms Brickfield, Rochdale, as one of the main sources of enrichment of our Coal-measure fauna. The spot in question is the Shipley Clay-pit, about 1½ miles north of Ilkeston, Derbyshire, situated on the Shipley Manor estate, and owned by E. H. Mundy, Esq., to whom, for his kindness in giving me opportunity to examine the nodules it contained, I am deeply indebted. The pit, which covers some two acres of ground, was opened in the yellow clays in the neighbourhood of the Top Hard Coal, probably some 30 to 40 feet below that seam. The clays abound in ironstone nodules, arranged in bands, every one of which, when broken, reveals the presence of some organism, either plant[1] or animal, in a perfect or fragmentary condition. It was found, however, that nodules which were more or less symmetrical, either round or ovoid, usually contained the most perfect specimens. To such an extent was this the case that, latterly, symmetrical nodules were collected and brought home to be broken at leisure by freezing or by other means, with most satisfactory results. Unfortunately the clay-pit is now disused and is totally obliterated by being filled with waste from an adjoining mine.

The following is a list of the animals obtained from the clay-pit; and it is curious to notice, purely as a coincidence, how closely it can be compared with a similar list given by Mr. W. Baldwin[2] for the Sparth Bottoms Clay-pit:—

ARTHROPODA.

CRUSTACEA—

PHYLLOPODA: *Leaia trigonioides*, sp. nov.

SCHIZOPODA: *Præanaspides præcursor*, Woodward.

MYRIAPODA:

Xylobius cf. *spinulosa*.

Xylobius sp.

Arthropleura, sp. nov.[3]

A. armata, Jordan.

INSECTÆ.

Insects' wings[4] with Blattoid and Lithomantid affinities. The latter, gen. et spec. nov.

[1] For list of plants found in this clay-pit see a paper by Mr. E. A. Newell Arber in the Proceedings of the Yorkshire Geological Society, vol. xvii, pt. ii, pp. 132–55, pls. xii–xix, 1910.

[2] W. Baldwin, "Fossil Myriapods of the Middle Coal-measures, Sparth": GEOL. MAG., Dec. V, Vol. VIII, p. 75, 1911.

[3] Professor Woodward has kindly undertaken to describe this specimen at a later date.

[4] Mr. H. Bolton has kindly undertaken to name and describe these wings at an early date.

ARACHNIDA—

XYPHOSURA:

Bellinurus bellulus, Koenig.
B. koenigianus, Woodward.
B. longicaudatus, Woodward.
B. sp.
Prestwichia anthrax, Prestwich sp.
P. rotundata, Woodward.
P. birtwelli, Woodward.

EURYPTERIDÆ:

Eurypterus moyseyi, Woodward.
E. derbiensis, Woodward.

SCORPIONES: Post-abdominal segment.

PEDIPALPI: *Geralinura britannica*, Pocock.

ARANEÆ: ? *Protolycosa* sp.

ANTHRACOMARTI:

Anthracosiro woodwardi, Pocock.
A. cf. *fritschii*, Pocock.

INCERTÆ SEDIS: *Cyclus* sp.

VERTEBRATA.

PISCES—

ELONYCHTHIDÆ: *Elonychthys* sp.

INCERTÆ SEDIS:

Fayolia cf. *dentata*, Zeiller.
F. crenulata, Moysey.
Palæoxyris prendeli, Lesquereux.
P. helicteroides (Morris).
Vetacapsula johnsoni (Kidston).

I would here desire to express my great obligation to Dr. Henry Woodward for assisting me in determining the specimens mentioned; also to Miss G. M. Woodward for the care and trouble she has taken in making drawings for the illustration of this paper.

V.—What is Laterite?

By L. Leigh Fermor, A.R.S.M., D.Sc., F.G.S., Geological Survey of India.

(*Continued from the October Number, p. 462.*)

Detrital Laterite or Lateritite.—Many of the so-called low-level laterites and some of the high-level laterites consist of admixtures of detritus from the various varieties of laterite already mentioned, with quartz and argillaceous detritus from granites and gneisses, the whole cemented together by the action of water on the lateritic constituents of the mixture. For such rocks the name *detrital laterite* is available, and could be used in all cases in which the reconstructed rock contained, say, at least 40 per cent of lateritic constituents. Theoretically, detrital laterites may contain, as an upper limit, 100 per cent of lateritic constituents, corresponding to the case of a detrital rock composed entirely of fragments of a pure laterite, without admixture of extraneous constituents. From the above it will be seen that I would allow greater elasticity in using the term laterite for the detrital forms than for those formed in situ (see next paragraph), provided the adjective *detrital* be carefully prefixed; for this word seems to me to imply the great variability of composition that must characterize these *secondary laterites*. But if it were considered desirable to avoid the use of the word *laterite* altogether in this connexion, the obvious term to use instead would seem to be *lateritite*, implying *a rock the individual constituents of which are pieces of laterite.* This term would be of great utility, and could be applied to all detrital and reconstructed lateritic rocks. The word is put forward here merely as a suggestion, but if geologists were to distinguish, in writing, between *laterite*, *lateritoid*, and *lateritite*, great clarity could be introduced into the literature of these substances.

Limiting Percentages.—The difficulty in attaching names to rocks intermediate between pure laterite and pure clay or lithomarge is to fix on limiting percentages, which must be chosen more or less arbitrarily. Considering the case of a rock that had been analysed, I should say that not more than about 10 per cent of non-lateritic material (i.e. quartz or lithomarge, in ordinary cases) or 5 per cent of combined silica (10·72 per cent of lithomarge is equivalent to 5 per cent of combined silica) should be allowed to pass without prefixing to the term *laterite* a qualifying adjective, such as *quartzose* and *lithomargic* respectively. Material containing more than half its weight of either lithomarge or of quartz could no longer be called *laterite*, but might be called *lateritic lithomarge*, *sand*, *soil*, or *earth*, if there were a sufficient quantity of free oxides of iron and aluminium present to justify the use of the qualifying adjective. Fifty per cent of lithomarge of formula $2 H_2O . Al_2O_3 . 2 SiO_2$ corresponds to 23·25 per cent of combined silica. Considering that, in India, as a rule, impure laterites are more commonly predominantly lithomargic than quartzose, I should not allow any rock, the analysis of which showed over 23·25 per cent of SiO_2 *of undetermined character*, to be classed as laterite, assuming, in the absence of evidence to the contrary, that the silica was present in the combined condition. For *lateritite* or *detrital laterite* I consider that greater freedom should be allowed, as already explained, and that these terms might be allowed to include detrital lateritic rocks containing as much as 60 per cent of non-lateritic constituents.[1]

Analyses by H. and F. J. Warth.—To exemplify the application of this nomenclature, we may refer to the most complete series of analyses of laterites yet published, namely that made by Dr. H. Warth, formerly of the Geological Survey of India, and his son, Mr. F. J. Warth.[2] This paper gives twenty-three analyses, divided into four groups—

I. "Pure Gibbsite" (No. 1).
II. Bauxites rich in Al_2O_3 and poor in Fe_2O_3 (Nos. 2 to 5).
III. "Laterites in situ which are Bauxites" (Nos. 6 to 13).
IV. "Detrital Laterites" (Nos. 14 to 23).

Groups I to III are *high-level laterites*. Sample 1 is practically pure *gibbsite*. Samples 2 to 5 show 67·88 to 57·50 per cent of Al_2O_3, 4·09 to 6·53 per cent of Fe_2O_3, and only 0·93 to 2·35 per cent of SiO_2. They are, therefore, correctly designated *bauxites*, and can also be termed *aluminous laterites*.

Samples 6 to 13 show 54·80 to 26·27 per cent of Al_2O_3, 13·75 to 56 01 per cent of Fe_2O_3, and 0·37 to 4·20 per cent of SiO_2. They all, therefore, like the samples of Groups I and II, are *true laterites*, except No. 10, which contains 10·52 per cent of quartz, and should therefore be designated *quartzose laterite*, although it is only just above the limit for true laterite. The authors call the rocks of this group "Laterites . . . which are Bauxites"; in my opinion, however,

[1] It is interesting to note that as long ago as 1838 Dr. J. Clark divided lateritic rocks into the three following classes: (1) lithomargic, (2) quartzy, (3) detrital. See *Madras Journ. Lit. and Sci.*, viii, pp. 338, 344.

[2] GEOL. MAG., 1903, pp. 154–9.

Nos. 11 to 13, which contain 47·27 to 56·01 per cent of Fe_2O_3, are not entitled to the term *bauxite*, but should merely be termed *laterite* without any qualification, or, if so desired, *ferruginous laterite*.

Samples 14 to 23, comprising Group IV, show 35·70 to 6·67 per cent of Al_2O_3, 8·77 to 47·39 per cent of Fe_2O_3, 7·96 to 23·32 per cent of combined silica, and 4·53 to 39·53 per cent of free quartz. The authors re-arrange these analyses in terms of the mineralogical composition of the rocks they represent; the samples are thus shown to contain 39·94 to 64·56 per cent of my "lateritic constituents" (termed by the authors "Balance identical with Bauxite"), whilst the balance of 35·44 to 60·06 per cent of non-lateritic constituents is made up of 4·53 to 39·53 per cent of quartz, and 50·26 to 17·16 per cent of "Clay as Kaolin", with occasional extremely small amounts of CaO. The average composition of these ten "detrital laterites" works out as—

Lateritic constituents . .	49·85
Lithomarge	30·11
Quartz	19·99
	99·95
CaO	0·05
	100·00

or approximately: lateritic constituents 50 per cent, lithomarge 30 per cent, and quartz 20 per cent. They are, therefore, on the average just at the upper limit for laterite, and might be termed comprehensively *siliceous laterites*.

Taking these ten samples individually, however, differences are recognizable. They may be divided into two groups of five each. In the first group (Nos. 15, 16, 17, 18, and 20) there is a much greater proportion of lithomarge (29 to 50 per cent) than of quartz (4 to 17 per cent), whilst in the second group the quartz (24 to 40 per cent) is either approximately equal to or else is greater than the lithomarge (17 to 30 per cent). Of the former division, No. 17 from Jabalpur (? district) contains 50·26 per cent of lithomarge, and should therefore be termed *lateritic lithomarge*. It is interesting to note here that the Ponri Hill lateritic lithomarges referred to later also come from the Jabalpur district. The four remaining samples—from Belgaum (two), Dharwar, and Birbhum—show over 50 per cent of lateritic constituents, and should be termed *lithomargic laterites*. These five rocks, with the possible exception of the Dharwar sample containing 17 per cent of quartz, are not, I suspect, of detrital origin, as stated, but were probably formed in situ under conditions in which the lateritizing processes were not pushed to a finish.

The other five samples (Nos. 14, 19, 21, 22, and 23) all show over 50 per cent and under 60 per cent of non-lateritic constituents (with the exception of No. 23, which contains only 24 per cent of quartz and 20 per cent of lithomarge, and might be designated *siliceous laterite*, or even *argillaceous quartzose laterite*). Judging from the analyses, they are probably detrital rocks, formed perhaps by the admixture of detritus from lithomargic laterite deposits with quartz sand, or by the admixture of detritus from true laterites with quartz and argillaceous detritus from gneissic or granitic rocks. The correct name for these rocks will be, then, *detrital laterite* or *lateritite*.

The Ponri Hill Lateritic Lithomarges.—As another example, I may refer to a series of superficial rocks found at Ponri Hill in the Jabalpur district, which I hope to describe later in the *Records of the Geological Survey of India* under the heading of *lateritic lithomarges.* On first examining this hill, I thought it was an occurrence of very aluminous laterite, and, consequently, took for analysis two bulk samples, representing the two principal varieties of the rock. I was much surprised, when the results of the analyses came to hand some three or four years ago, to see that the samples contained, respectively, 24·60 per cent and 31·90 per cent of SiO_2; but I at once decided that, in spite of their superficial resemblance to true laterite, both in physical appearance and in the ease with which they could be cut into blocks for building purposes, these rocks could not be regarded as laterites. Closer inspection was sufficient to show that the groundmass of the rock consisted of a compact, somewhat horny, substance corresponding to the lithomarge, the presence of which was indicated by the analyses, and that the rock consisted of patches of lateritic material distributed through a lithomargic base. The analyses are given below, together with that of a third example, in this case a hand-specimen of a white pisolitic rock, collected by Dr. Maclaren at Mendil near Talevadi in the Belgaum district of the Bombay Presidency. The Mendil specimen was forwarded by me to Messrs. J. and H. S. Pattinson of Newcastle for analysis with my samples of manganese-ore, whilst I was Curator of the Geological Museum. Dr. Maclaren and I were both under the impression that this specimen was a piece of very high-grade bauxite, and had not the slightest suspicion of its siliceous nature. As will be seen from the following table, in which are given also the analyses of the samples from Ponri Hill, the Mendil specimen contains a very large amount of silica:—

	Ponri Hill.				Mendil.	
Number of Sample.	A. 13.		A. 14.		J.M.M.	
SiO_2 . .	24·60	98·29	31·90	98·77	42·90	99·07
Al_2O_3 . .	28·04		30·98		39·20	
H_2O . .	12·50		12·65		14·13	
Fe_2O_3 . .	26·79		18·25		0·40	
TiO_2 . .	6·21		4·79		2·34	
Mn_3O_4 . .	0·15		0·20		0·10	
K_2O . .	0·01	1·46	0·01	1·48	nil	1·03
Na_2O . .	0·13		0·19		0·09	
P_2O_5 . .	0·16		0·19		0·17	
CO_2 . .	trace		trace		0·03	
Moisture .	1·16		1·09		0·74	
	99·75		100·25		100·10	

Unfortunately the siliceous nature of these three rocks was not suspected at the time the samples were despatched for analysis, and consequently no instructions were issued to the analysts to determine separately the combined and free silica. There can be no doubt, however, judging from the microscopical examination, that practically all the silica is in the combined condition, for no evidence was seen of any free silica. These analyses have consequently been re-arranged in terms of their mineralogical composition on the following assumptions, which are fully justified in the light of the macroscopical and microscopical examination of the specimens. The whole of the silica has been calculated as lithomarge,[1] of the formula $2\,H_2O\,.\,Al_2O_3\,.\,2\,SiO_2$, and any alumina left over has been combined with the amount of the remaining water requisite for the formation of gibbsite. With the aid of any remaining water the ferric oxide is divided into limonite and hæmatite. The TiO_2 is returned as such, because little is at present known as to the form in which this constituent exists in laterite.[2] The item entered up by the analysts as 'manganese oxide' is assumed to have been determined as Mn_3O_4, and as it was not visible as a separate constituent in the samples, and is present in but very small quantities, it is reported as such in the mineralogical re-arrangement. The remaining constituents shown in the analyses are neglected, being trivial in quantity, and necessary neither for laterite nor lithomarge. The re-arranged analyses are as follows:—

		Ponri Hill.			Mendil.	
		Lateritic lithomarges.			*Lithomarge.*	
		A. 13.		A. 14.		J.M.M.	
Lithomarge		52·75		68·40		91·99	
Gibbsite	Lateritic constituents	11·05	45·54	6·10	30·37	4·24	7·08
Limonite		9·27		7·13		nil	
Hæmatite		18·86		12·15		0·40	
TiO_2 .		6·21		4·79		2·34	
Mn_3O_4 .		0·15		0·20		0·10	
Minor constituents (non-lateritic)		1·46		1·48		1·03	
		99·75		100·25		100·10	

[1] As seen under the microscope in thin sections, the aluminous silicate is isotropic wherever it shows any translucency or transparency, and it cannot therefore be designated kaolinite, which is a crystalline mineral. Substances corresponding to Dana's description of *lithomarge*, which he gives as a variety of kaolin, are invariably, in my experience, amorphous and non-crystalline, and consequently I think that lithomarge is to be regarded as the colloidal variety of kaolinite.

[2] Some authors assume its presence as ilmenite, e.g. Professor Harrison in his paper on the lateritic earths of British Guiana; but it cannot be present in this form in many of the Indian laterites. Reference to the analyses of aluminous laterites given in Rec. Geol. Surv. India, xxxii, p. 179, and xxxvii, p. 215, shows that in the majority of these laterites there is insufficient iron present for all the titanium to be in the form of ilmenite. Further, I have seen no evidence under the microscope of the existence of ilmenite in laterites, and, in fact, as far as I have seen, the high amounts of titanic oxide in some

Each of these three analyses shows more lithomarge than lateritic constituents, and consequently, according to what precedes, the Ponri rocks are most correctly described as *lateritic lithomarges*, whilst the Mendil specimen is a *lithomarge*, without any qualifying adjective.

Other examples.—For further examples amongst Indian laterites reference may again be made to the analyses referred to on p. 460. All the rocks represented by analyses in Dunstan's paper are correctly described as *laterites*, and can also be termed *aluminous laterites* or *bauxites*. The term *laterite* can also be applied without qualification to all the rocks represented by analyses in Holland's paper, with the exception of samples D, E, and G, containing respectively 14·58, 19·32, and 10·75 per cent of $Si\,O_2$. These silica percentages, assuming the whole of the silica to be combined silica, all lie above the 5 per cent limit given above, but below the 23 per cent limit, and the rocks should therefore be described as *lithomargic laterites*, the silica percentages corresponding to 31·26, 41·43, and 23·05 per cent of lithomarge; sample B, containing 4·68 per cent of $Si\,O_2$, corresponding to 10·03 per cent of lithomarge, is near the borderline at which I would prefix the adjective 'lithomargic'. These lithomargic laterites are all from the Madras Presidency, three of them coming from the Palni Hills and one from the Vizagapatam Hill Tracts.

Reference may also be made to three other analyses, namely, those of three aluminous laterites or bauxites from the Yeruli plateau, Satara district.[1] One of these contains 5·20 per cent of silica, and, therefore, assuming it is combined silica, as is probably the case, just comes within the limits of *lithomargic laterites*. Apart from this constituent, however, the rock is a fairly high-grade *bauxite*. The other two samples are true laterites, containing only 2·63 and 1·10 per cent of $Si\,O_2$ respectively. Noteworthy is the presence of 0·63 and 0·13 per cent of $Cr_2\,O_3$ in these two latter rocks; *chromium sesquioxide* must, of course, be regarded as a true lateritic constituent.

Lateritic earths.—For many mixtures of clay and sand with iron and aluminium oxides it is quite unnecessary to use the term *laterite* at all, more suitable terms being *ferruginous clay*, *loam*, or *sand*; where the free oxides are high in amount, the terms *lateritic clay*, *lateritic soil*, *lateritic earth*, etc., are available.

Buchanan's original definition.—It will be noticed that I have so far made no reference to Buchanan's original definition. This has

laterites do not make their presence evident in any form in thin sections of the corresponding rocks. Consequently I am inclined to think that the titania is present as a collodial constituent, either as a hydrated oxide of titanium, or even possibly as a hydrated aluminium titanate, of composition parallel to that of kaolin and lithomarge, although this latter alternative is put forward as a mere suggestion, for which there is at present no evidence. Whether the titania be present as a hydroxide or as a collodial titanate does not matter for our present purpose, as the above analyses are susceptible of arrangement to agree with either alternative. I find that M. Arsandaux (note, *infra*) supposes the titania of French bauxites to be present as metatitanic acid, $Ti\,O_2$, $H_2\,O$.

[1] Mem. Geol. Surv. India, xxxvii, p. 378.

already been quoted by Mr. Crook,[1] whilst Dr. Evans[2] puts the matter in a nutshell when he says—

"Buchanan found a rock widely extended in India which was unlike anything with which he was familiar, and he thought that it required a name. As bricks were made of it (not because it resembled a brick) he called it laterite, certainly without intending to include under it all materials of which bricks could be made. I admit that he did not know its true chemical composition, but in spite of that it must be accepted as the type of what we ought to call laterite."

Buchanan's term was adopted by Indian geologists, and has been widely applied in many parts of India; laterite has consequently been described in very numerous papers on Indian geology,[3] but until the last few years without much knowledge on the part of the authors of the chemical composition of the rock; it follows, therefore, that this term has sometimes been applied to rocks that, had they occurred in a temperate clime, would have been called by some more ordinary name, such as clay, lithomarge, iron-ore, etc.

Mr. Philip Lake, in the Appendix to his memoir on the *Geology of the South Malabar*,[4] says—

"Some writers appear to restrict the term to rock formed in some particular way, and to exclude all laterite rocks that can be shown to have originated in any other manner. But the name, as originally proposed by Buchanan, appears to have been a pure lithological term, for he does not discuss the mode of origin. If any rock is, in hand specimens, undistinguishable from laterite, there is no reason why it should not be called laterite whatever its mode of origin may have been.

"Other writers, on the other hand, have used the term too laxly, and have called rock laterite which should rather be called *lateritic*;[5] but it must be admitted that it is hard to draw a line between laterite containing pebbles and a conglomerate in which the pebbles are cemented together by laterite."

As long as no chemical work had been carried out on laterite it was necessary to accept Lake's view that any rock indistinguishable from laterite in hand-specimens should be called by this name. But now that we have chemical information on the composition of these rocks it seems necessary to use more discrimination, and in refusing the term *laterite* to lithomarges, and in advocating the qualification by the adjective *lithomargic* of those laterites containing considerable quantities of this mineral, we shall be acting in spirit with Buchanan, who would not have wished to comprise under one term such dissimilar substances as lithomarge and the mixture of hydrated oxides to which the term *laterite* should be restricted; we are also not departing far from Lake's view, for when once one has established by the aid of analysis the difference between true laterites and those containing a considerable quantity of lithomarge, and between both of these and rocks that are almost wholly lithomarge, it is easy in most cases to recognize the differences in hand-specimens; in any case it is not difficult to make a qualitative test for combined silica in any doubtful case.

[1] GEOL. MAG., 1909, p. 525. [2] Loc. cit., 1910, p. 381.

[3] Résumés of this work and of that of other previous writers are to be found in the following works: P. Lake, "Geology of South Malabar," Appendix (Mem. Geol. Surv. India, xxiv, pp. 239–46, 1891); G. C. Du Bois, "Beitrag zur Kenntnis der surinamischen Laterit, etc." (Tschermak's Mitt., xxii, pp. 4–18, 1903); C. Guillemain, "Beiträge zur Geologie von Kamerun" (Abh. König. Preuss. Geol. Landesanstalt, N.S., vol. lxii, pt. viii, on Laterite, pp. 242–323).

[4] Mem. Geol. Surv. India, xxiv, p. 239, 1891. [5] The italics are mine.

TABLE I.—THE NOMENCLATURE OF LATERITES AND SOME OTHER SURFACE ROCKS.

Chemically-formed rocks.							Transported rocks (mechanically formed).[1]		
Original rocks.	Mode of formation.	I. Lithomarge, clay, soils, etc. < 25 % L.C.	II. Lateritic rocks. 25–50 % L.C.	III. Siliceous laterites (and lateritoids). 50–90 % L.C.	IV. True laterites (and lateritoids). 90–100 % L.C.	V. Varieties of IV.	Original rocks.	VI. Detrital laterites (lateritite). 40–100 % L.C.	VII. Soils and lateritic earths. < 40 % L.C.
Basic rocks— Basalts, dolerites, gabbros, basic gneisses, hornblende-schist, etc.	Weathering in situ.	**LITHOMARGE, CLAY**, soils, sands, earth, and partially decomposed rocks.	*Lateritic lithomarge* and clay. Lateritic soil.	**Lithomargic laterite.**	True **LATERITE.**	Bauxite, iron-ore, manganese-ore.	Any of Groups I to V, alone, or mixed with extraneous material.	**DETRITAL LATERITE** (Lateritite).	Clays, soils, sands, earths, etc. (*lateritic*, if 25–40 % L.C.).
Acid rocks— Granites, gneisses, mica-schists, etc.			*Quartzose lateritic lithomarge.* Lateritic soil.	**Quartzose laterite.** (sometimes lithomargic as well).					
Any rocks that yield iron (manganese and aluminium) to meteoric waters.	Chemical deposition in lakes.	...		Siliceous lake laterites.	**LAKE LATERITE.**	Pisolitic limonite, (manganese-ore), (bauxite).			
Mica-schists, quartzites, etc.	Metasomatic replacement.	Quartzites and schists become mixed with Fe and Mn oxides, and pass into *lateritoid* '*breccias*' and these into III.		*Quartzose and sericitic lateritoids.*	**LATERITOID.**	Iron-ore, manganese-ore.			

NOTE. L.C. denotes 'lateritic constituents'.

[1] Frequently with cementing by chemical re-arrangement of the lateritic material.

Table.—The conclusions drawn above on the nomenclature of laterites are summarized in the accompanying table, which is self-explanatory. The limits between the various groups have, of course, been arbitrarily fixed, and might be adjusted to suit local convenience, but not to any serious extent.

Lateritoid.—Through manganese-ores and iron-ores, the laterites are related to the rocks I have called *lateritoid*, shown in the lowest line of the table, and as I consider it rather important to distinguish between those two related rocks I will quote in full my original account of lateritoid [1]—

"Of the many occurrences of lateritic manganese-ores that I have been able to examine, only three were in what would be called 'laterite', without any hesitation, by all geologists. These three were in the low-level laterite of Goa; in the high-level laterite of Talevádi in Belgaum; and near Gosalpur in the Jabalpur district in laterite that must, I suppose, be called 'high-level', although it is only at a level of about 1,300 to 1,400 feet. The remainder occur in a rock that some geologists would probably designate 'laterite'; but others would probably object to the application of the term. The rock to which I refer has a lateritic aspect and usually consists of a cavernous mixture of various oxides of iron, chiefly hard limonite, yellow ochre, and soft hematite. When no other constituents are present, the rock often resembles typical laterite in its structures and mineral composition so closely that when detached from its rock masses it could not be distinguished from pieces of ordinary ferruginous laterite (of non-detrital origin). Fairly often, however, it contains ores of manganese, either wad, psilomelane, or pyrolusite. The iron-ores and manganese-ores are mixed with one another in a very irregular manner. Veins and patches of the manganese-ores sometimes occur in the iron-ores, whilst in other places veins and patches of iron-ores occur in a mass consisting chiefly of manganese-ores. Owing to the cavernous character of the rock the limonite and psilomelane have often been able to develop marked concretionary structures, such as botryoidal or stalactitic, whilst the pyrolusite is often in small crystalline aggregates. This rock does not always consist entirely of iron and manganese-ores. It often contains patches of quartz, quartzite, slate, or phyllite. Examination with the microscope shows that these rock-patches are residual pieces of rock set in a matrix of ore, and that the latter has evidently been formed by their replacement. Examination of the masses of rock in the field, especially as revealed in the workings for manganese, confirms this deduction, and shows that there is a downward passage from the lateritic mass of iron and manganese-ore at the surface through rock containing more and more quartzite, slate, or other rock, and less and less ore, to a rock that is free from all signs of ore. The junction between the overlying lateritic mass of rock and the rock on which it rests is consequently an extremely irregular one. There is, in my opinion, no doubt that these lateritic masses have been formed by the metasomatic replacement of the quartzite, slate, or phyllite, accompanied by segregative changes. And as these rocks do not usually contain more than a very small proportion of, and often no, manganese, it is evident that the manganese must have been largely brought in from outside by percolating waters, with the resultant replacement from the surface downwards of the particular rock that happened to be at the surface where the replacement took place. These lateritic replacement deposits nearly always occur as cappings to small hills, the actual rugged surface of the rock (often spotted with lichens) being approximately horizontal. These caps do not, however, show signs that they are the remains of a horizontal sheet, for they occur at different elevations on neighbouring hills, and as noticed above have a very irregular base. And although there are doubtless many cases where such a cap has been cut into two by erosion, yet most of the occurrences suggest that they have been formed

[1] Mem. Geol. Surv. India, xxxvii, pp. 381–3, 1909.

independently of other masses of this lateritic rock. On account of the limited extent of each of these masses of rock, their different elevation, their want of horizontal bases, and the numerous cases in which the rock contains residual angular fragments of other rocks, most geologists would probably prefer to consider these occurrences as distinct from the masses of typical laterite occurring in horizontal sheets, often of considerable extension, and free from included fragments of rock different in character from the laterite. For this reason I propose to refer to these occurrences under the name of *lateritoid* to indicate their similarity to laterite. It is to be noted that, were they to be designated 'laterite', they would by their position come into the high-level laterite division. From what I have written above it is evident that my view of the origin of these masses of lateritoid and their included manganese-ores is practically identical with Maclaren's theory of the origin of laterite in general. He bases his theory particularly on the occurrence at Talevádi in Belgaum. I have visited this occurrence myself, and although the sections were no longer so good as when Maclaren went, yet I saw sufficient to make me agree with his description of the occurrence. Although the occurrence was in an area where the laterite seemed to occur as a large spread, yet I could not see any difference between the mode of occurrence of the manganese-ores here and those in the lateritoid deposits. From this it will be seen that the Talevádi occurrence may be regarded as a connecting link between the lateritoid caps containing manganese-ores and the large spreads of high-level laterite usually free from manganese-ore. I think, however, it is more closely related to the lateritoid occurrences than to the large spreads of high-level laterite in which bauxite is so often found."

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

NOTICES OF MEMOIRS.

I.—Jurassic in the Western Caucasus.

[Translated from the Russian by Felix Oswald, D.Sc., B.A., F.G.S.]

ALTHOUGH Jurassic strata reach a very extensive development in Daghestan and in the Central Caucasus, it is only within recent years that Russian geologists (N. I. Vorobiev in 1906, I. P. Tolmachev and M. Volosatov in 1907) have definitely proved the existence of Middle Jurassic beds in the western part of the Caucasus, viz. in the valley of the Little Laba, in the Psebai district (Maikop division of the Kuban province), where they overlie the Triassic strata described in the Geological Magazine, Dec. V, Vol. VI, No. 538, pp. 171–3, April, 1909. The fossils (now in the Peter the Great Museum at St. Petersburg) have been determined by B. Rebinder in a paper written in Russian ("Trav. Mus. géol. Pierre le Grand, St. Petersb.," ii, pp. 53–60, 1908), which I have translated and briefly summarized in the following abstract.

The Jurassic of the Little Laba valley extends for 3 miles below Psebai, forming the line of the Gernegem Heights, which are traversed and partly dissected by the Little Laba and its small tributaries. The valleys of these tributary streams are named in successive order from north to south: Lazaret, Marin, Sushkov, Vorov or Razboinich, and Solen. The general slope of the country roughly coincides with the north-east dip of the Jurassic strata, and hence the limestones rise to increasingly greater heights when traced southwards towards Psebai, so that in the southernmost of the tributary valleys, viz. Lazaret, the underlying series of shales with sphærosiderite nodules is exposed beneath the limestones, which form craggy heights, liable to slip over the clays. In the more northern valleys the limestones occur in the bed of the valleys, and are there overlain by a very thick series of clays with gypsum, apparently of Miocene age. Above Psebai the Little Laba cuts through a thick series of sandstone (with plant-remains) underlying the shales and resting upon Triassic limestones.

The Jurassic succession of the Little Laba valley may be thus tabulated from Rebinder's lists:—

1. *Oxfordian and Sequanian.*—Light brownish grey limestones, very fossiliferous, with an assemblage in which Oxfordian forms predominate, but there is a sprinkling of Lower Sequanian species such as *Zeilleria pseudolagenalis*, *Terebratula Zieteni*, and *Balanocrinus pentagonalis*, *Phylloceras*, sp. ind., *Peltoceras* cf. *arduennense*, d'Orb., *Perisphinctes bernensis*, Lor., *P. consociatus*, Buk., *P.* cf. *lucingensis*, Favre, *P. mazuricus*, Buk., *P.* cf. *Michalski*, Buk., *P.* cf. *tizianiformis*, Choff., *P.* aff. *plicatilis*, d'Orb., *P.* aff. *biplex*, *Dentalium*, sp. ind., *Ceromya excentrica*, Boem.,* *Lima Escheri*, Moesch, *Hinnites velatus*, Gf.,* *Plicatula*, sp. ind., *Terebratula Rollieri*, Haas, *T.* cf. *Zieteni*, Lor., *Zeilleria pseudolagenalis*, Moesch, *Waldheimia*, sp. ind., *Dictyothyris*, sp. ind., *Rhynchonella lacunosa*, Qu.,* *Holectypus*, sp. ind., *Pentacrinus cingulatus*, Münst., *P.* cf. *Marcousanus*, d'Orb., *Balanocrinus pentagonalis*, Gf., *Millericrinus* cf. *icaunensis*, Lor., *M. Escheri*, Lor.,* *Serpula*, sp. ind., and sponge-fragments. Those marked with an asterisk pass also upward into the Sequanian.

2. *Bathonian and Callovian.*—Yellow-grey to rusty-brown sandy limestones, yellow-grey oolitic limestones with geodes of limonite, and sandstones, sometimes argillaceous, with the following Bathonian forms occurring in the limestones: *Belemnites* aff. *canaliculatus*, Schl., *B.* cf. *würtembergensis*, Opp., *B.* aff. *Jacquoti*, Terq. & Jourdy, *Pleuromya donacina*, Röm., *Pseudomonotis*, sp. ind., *Gervillia*, sp. ind., *Rhynchonella varians*, Sow., var. *spathica*, Desh., *Terebratula* aff. *sphæroidalis*, Sow., *T. sphæroidalis*, Sow., mut. *balinensis*, Szajn., *T.* cf. *ventricosa*, Hartm., *Cidaris filograna*, Ag.

In this series the presence of Callovian (*Macrocephalus* zone) is clearly indicated by the following fossils: *Stephanoceras coronatum*, Brug., *Quenstedticeras*, sp. ind., *Pecten fibrosus*, Sow., *Cyclocrinus macrocephalus*, Qu.

3. *Bajocian.*—(i) Dark-grey shales with nodules of sphærosiderite (up to 0·20 m. in thickness), which frequently contain ammonites. The following fossils were obtained from this series: *Belemnites giganteus*, Schloth., *B.* aff. *paxillosus*, Qu., *Parkinsonia Parkinsoni*, Sow., *Pœcilomorphus* aff. *macer*, Buckm. (ii) Sandstones with plant-remains, overlying Triassic strata. A seam of lignite, 7 inches thick, has been recorded from these beds, in the Kizilovaya valley near Psebai.

The entire palæontological succession is closely parallel to that of Khod near Alagir on the north slope of the Central Caucasus, about 80 miles to the south-east.

Rebinder expresses strong doubts as to the presence of Kimeridgian in the Jurassic of the Little Laba, for in his lists the only species which range so far upwards are *Ceromya excentrica*, *Terebratula* cf. *Zieteni*, and *Zeilleria pseudolagenalis*, but these are all more characteristic of a lower horizon. Moreover, it would indeed be a matter for surprise if Kimeridgian fossils had been discovered, for the Kimeridgian was not a period of deposition in the Caucasian area but one of earth-movements and folding of strata. It is one of the sharpest distinctions between the stratigraphy of the two slopes of the Caucasus that whereas on the south slope the interruption takes place only after the Sequanian and lasts until the Neocomian, on the north slope on the other hand Tithonian beds are well developed and rest discordantly on Lower Sequanian.

II.—The Glacial Period and Climatic Changes in North-East Africa.[1]

By W. F. Hume, D.Sc., F.R.S.E., and J. I. Craig, M.A., F.R.S.E.

1. *Southerly Shift of the Wind-systems in Glacial Times.*—The effect of the seasonal decrease of temperature in the Northern Hemisphere is to cause a seasonal displacement of the system of westerly moist winds southwards by several degrees, and not improbably decrease of temperature below its normal is also associated with a similar displacement. It is inferred that the decrease of temperature of the Glacial Period would be correlated with such a displacement of the westerly winds, which now barely touch the north coast of Egypt in the winter, that they would impinge on the loftiest portion of the Red Sea mountain range.

Geological and topographical evidence points conclusively to the existence of such a westerly moist current at no very distant period. The current was westerly, for the principal erosion occurred on the western slopes, and this erosion is evidenced by the gravel terraces, which attain a remarkable development near the town of Qena. These consist of materials which could have come only from the highest portion of the Red Sea Hills, distant some 40 to 50 miles to the east or north-east. The precipitation was most active where the range is highest, and decreases towards the north where the mountains are lower. The decrease towards the south is to be attributed more probably to an approach to the southern limit of the moist current.

Further evidence of such a westerly current is to be found in the existence of calcareous tufas on the border of the eastern scarp of Kharga Oasis and elsewhere, and that the temperature was then several degrees colder is shown by the presence in the tufas of leaf-fragments of *Quercus ilex* and other plants which do not now flourish south of Corsica and Southern France.

2. *Change in Monsoon Effects during the Glacial Period.*—There is evidence of the enormous development of glaciers over Ruwenzori, Mount Kenia, Kilimanjaro, and the Himalayas, during the Glacial Period. The recession of the glaciers in East Africa indicates that the temperature there is now about 10° to 12° F. warmer than during the period of maximum glaciation.

It is known from the investigations of the Meteorological Department of India that an increased snowfall on the Himalayas in spring exercises a measurable prejudicial effect on the Indian monsoon at the

[1] Read before Section C (Geology), British Association, Portsmouth, September, 1911.

present day, and we may infer that the enormously greater ice-covering of the Glacial Period would exercise a much more powerful inhibition on the monsoon of that period. The more extensive ice-sheet of East Africa, by preventing abnormal heating of the land in summer, would act still further in the same direction, and it is extremely probable that the monsoon current partook of the southerly displacement of the wind-system referred to above. The general result would be a decreased precipitation over Abyssinia, and a much reduced Sobat, Blue Nile, and Atbara, which at present account for 96 per cent of the flood proper of the Nile.

The geological history of the Nile entirely accords with the above inferences. One of the chief results of the present monsoon rainfall has been the deposit of finely divided muds brought from the Abyssinian hills, in the Nile valley. To the south of Cairo these deposits are at most of 30 to 35 feet thickness, of which 10 feet have been laid down since the time of Ramses II. If conditions have remained uniform, this would give a date fourteen thousand years ago for the first deposits of alluvial muds in Egypt. Previous to this the mud-laden waters of the Abyssinian Nile system did not reach Egypt, just as the waters of Khor Gash now fail to reach the Nile, and so geology and meteorology concur in indicating a much weaker rainfall in Abyssinia during the Glacial Period.

III.—Index Generum et Specierum Animalium.[1]

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

Since the 1910 Report systematic search through literature has proceeded up to the letter E. Further, a group of especially troublesome and difficult books have been dealt with, e.g.: Oken's *Isis*, 41 vols., 1817–48; Froriep's *Notizen*, 102 vols., 1821–50; Ersch & Gruber, *Allgem. Encyclopaedie*, 103 vols., 1818–50; and many other volumes have been indexed out of the general order as asked for or required—as, for instance, the works of Jacob Huebner, which are now in Mr. Sherborn's hands in hope that he may obtain some further information as to the dates of their publication.

The search for rare literature continues, and Mr. Sherborn desires to thank Dr. Karpinski for obtaining for him the second volume of the *Trudui* of the St. Petersburg Mineralogical Society, 1831; Dr. Bashford Dean and Mr. O. F. Cook for a complete set of *Brandtia*, 1896–7, both of which works will find a resting-place in the British Museum (Nat. Hist.) when done with. He also desires to thank Mr. Tom Iredale for much valuable help in obscure bird genera.

The following papers have been written in connection with the Index:—

"On the Dates of Publication of Costa's *Fauna del Regno di Napoli*, 1829–86": Ann. Mag. Nat. Hist. (8), v, p. 132, 1910.

"A Collation of J. C. Chenu's *Illustr. Conch.*, and a note on P. L. Duclos' *Hist. nat. gén. et part. coquilles*" (with Mr. Edgar A. Smith): Proc. Malac. Soc., ix, March, 1911.

[1] Read before Section D (Zoology), Brit. Assoc., Portsmouth, September, 1911.

"Note on John Curtis' *British Entom.*" (with Mr. J. Hartley Durrant): Entom. Month. Mag., xlvii, April, 1911.

Your Committee confidently recommend their reappointment, and earnestly ask the Association further to support this valuable work by a renewed grant.[1]

IV.—On some New Rhætic Fossils from Glen Parva, Leicestershire. By A. R. Horwood.[2]

Owing to the impending filling up of the once fine pit at Wigston (Glen Parva), where the Keuper tea-green marl, Rhætic, and Lias formations are all exposed in a fine section of some eighty feet of rock, extraordinary efforts have been made by Messrs. A. J. Cannon and H. Siddons to investigate the contents of the bone-bed and black shales of the Rhætic before this is rendered impossible by the filling up of the pit with water, the brickyard being now closed.

Some rare and new fossils have been found which may here be briefly mentioned. In the tea-green marls *Orbiculoidea Townsendi* was discovered. This, along with the regular occurrence there of bands of fish scales and teeth in the same beds, and of *Estheria minuta*, allies them palæontologically with the Rhætic beds in which alone the first fossil has hitherto been found.

In the succeeding black shales amongst many plant fragments are some leaves allied to *Podozamites*, which are new. An exceedingly interesting discovery is the impression, unique as such for Palæozoic or Mesozoic rocks, of an annelid which occurs in beds filled with castings allied to *Arenicola*. Among Arthropodous remains are the chitinous body-segments of Crustacea and a scorpion-like creature. That they are not uncommon elsewhere is probable. But the Rhætic fauna is so fragmentary and generally so depauperated and stunted that the most careful search is required.

Ophiolepis Damesii, not definitely found in situ here before, has occurred, and with it some other Echinoderms which may be new. Many fine examples of *Pholidophorus Higginsi* have been secured which exhibit the dermal armature well, and also the fins. Some curious concretionary structures, homœomorphs of orthoceratoid segments, occur here also. The usual fauna already described has been obtained, some fine examples of each species having been collected. It is hoped to describe the new forms very shortly.

V.—On the Discovery of Remains of *Iguanodon Mantelli* in the Wealden Beds of Brighstone Bay, I.W., and the Adaptation of the Pelvic Girdle in relation to an Erect Position and Bipedal Progression. By R. W. Hooley.[2]

The specimen of which the paper treated was discovered by the author in 1899; it includes the sacrum, lumbar, and caudal vertebræ, bones of the pelvic girdle, and the left femur. The

[1] A further grant of £75 was made at the Portsmouth Meeting, and Dr. W. T. Calman was added to the Committee.

[2] Read before Section C (Geology), British Association, Portsmouth, September, 1911.

characters shown by the fossil prove the remains to belong to *Iguanodon Mantelli*, but all examples hitherto found have manifested this species to be much smaller than *Iguanodon Bernissartensis*, whereas the bones discovered belonged to a reptile equalling, if not exceeding, the dimensions of that species. Among the skeletons of Iguanodons found at Bernissart in 1878, M. Dollo found a small and a large form. The former resembled in all points the type-specimen of *Iguanodon Mantelli*; and he thought that the differences between the two forms were specific and not sexual. This specimen opens the question again, and the author criticized the evidence, and inclined to the opinion that the osteological variations are sexual and that *Iguanodon Bernissartensis* is probably a synonym of *Iguanodon Mantelli*.

The second part of the paper dealt with the adaptation of the Iguanodont pelvis to enable an upright position and progression, and discussed the variations in the Dinosaurian pelvis.

REVIEWS.

I.—Iron Mines and Iron Mining in New Jersey. By William S. Bayley. [Vol. VII of the Final Report Series of the Geological Survey of New Jersey; Henry B. Kümmel, State Geologist. Trenton, N.J., 1910.]

THE object of this Report is to record in one volume the principal facts relating to the distribution and mode of occurrence of the iron-ores in the State. The records scattered through forty volumes of Annual Reports have been examined and utilized wherever expedient. The history of every mine, so far as known, has been briefly mentioned, and practically every iron-working has been visited. The commercial analyses have been tabulated and more complete ones have been added. The volume in short contains a most valuable summary, including much new information, of all that is known of the New Jersey iron-ores, with references also to opinions concerning their origin.

The ores comprise Bog Iron-ores, Brown and Red Hæmatites, and Magnetic Iron-ores. The history of the mining dates back to 1685, soon after English settlers first entered the borders of the State. The Bog Iron-ores were then worked. They comprise impure hydrated oxides, accumulated in bogs and swampy places where iron-bearing solutions were exposed to the action of the atmosphere. It is noted that within recent years the ore has met with some favour as a road metal, "a use to which it is well adapted when properly mixed with sand."

Brown Hæmatites or Limonites have been worked to a small extent, chiefly in the Kittatinny Limestone of the Cambrian, in cracks and in lenticular masses along bedding-planes of the strata, near their contact with the underlying gneisses. At the Edsall Mine the ore appears to be in the white Franklin Limestone of the Algonkian, near its contact with gneisses. Elsewhere it has been found in Cambrian slates and quartzites. It has nowhere been worked to any large extent.

Still less has the Red Hæmatite been worked. It occurs in shaly rocks, quartzites, and quartzose conglomerates associated with the Franklin Limestone.

The chief ores worked are the Magnetic ores or Magnetite-bearing rocks, and these are associated either with the white or grey crystalline limestone or marble of the Franklin formation, or with the gneisses and pegmatites. It is inferred that these latter are the younger, and were intruded into the Franklin formation.

The production of iron-ore was estimated at 10,000 tons in 1790; the largest yield, 932,762 tons, was in 1882; and in 1908 the yield was 432,566 tons, almost entirely magnetic iron-ore.

The volume is accompanied by two geological maps (scale 1 inch to a mile) of the eastern and western sections of the New Jersey Highlands, showing the distribution of the principal types of Pre-Cambrian rocks and the localities of iron-ore deposits.

II.—Prehistoric Society of East Anglia.

THE first part of the Proceedings of this Society for 1908–10 has lately been issued (H. K. Lewis, 136 Gower Street, W.C., 1911, price 3*s.* 6*d.* net), under the editorship of the Honorary Secretary, Mr. W. G. Clarke.

Among other articles it contains a paper on "The Flint Implements of Sub-Crag Man", by Mr. J. Reid Moir. He claims to have found "definitely well-worked flints (which are far in advance of the Kentian Eoliths) in their true stratigraphical position below Crag". The deposit in question is that grouped by Mr. F. W. Harmer as the Newbournian zone of the Red Crag. The flints have been found under shelly crag, 13 feet and more in thickness, at Greenwich Farm and the Black Hamlet, Ipswich, and at Thorington Hall, Wherstead. Mr. Whitaker, Dr. Marr, and Professor Watts visited the Thorington Hall pit with Mr. Moir and pronounced the strata to be in situ. In another section, at the Brickyard of Messrs. Bolton and Laughlin north of Christchurch Park, Ipswich, worked flints were found on a surface of London Clay beneath a basement stone-bed of the Red Crag, with phosphatic nodules, bones of whale, mastodon, etc. Here, again, Mr. Whitaker and Dr. Marr express the opinion that the stone-bed "is the undisturbed base of the Red Crag". The London Clay below and in other parts of the pit exhibits much contortion and some evidence of thrust-planes, and the same authorities admit that the disturbances are due to ice-action, "although no such disturbance has affected the relative position of the London Clay, the Crag, and the Glacial Drift." The carefully drawn diagram by Mr. George Slater, however, does not lend support to this view, as a portion of the basement crag is represented as incorporated with the Boulder Drift. We are not, therefore, surprised to read that Professor Bonney came to the conclusion that the Crag deposits in the brickyard "are not in situ, but owe their present position to later geological disturbances". It is noteworthy that on the surfaces of the sub-crag flints there are striations attributed by Mr. Moir to ice-action, and he concludes that we may have "to recognize a glaciation in early Pliocene or pre-Pliocene times".

With regard to the flints themselves, of which illustrations are given in six plates, the evidence of man's work is recognized by Sir E. Ray Lankester, Dr. Blackmore, Dr. W. Allen Sturge (President of the Society), Dr. F. Corner, Mr. A. S. Kennard, and others; while Professor Boyd Dawkins and Mr. S. Hazzledine Warren regard the flakings as the result of natural forces.

The record of facts and the inferences are very carefully and fairly stated by Mr. Moir, and his paper is followed by the Report of a Special Committee of the Society appointed to inquire into the question whether the flints had been chipped by natural or by human agency. The verdict was in favour of human agency.

III.—Flora of the Little River Group, No. III. By G. F. Matthew, D.Sc., LL.D. Trans. Roy. Soc. Canada (iii), vol. iv, sect. iv, p. 3.

THIS paper gives an "Analysis of the flora of the Little River Group, with Description of *Pseudobaiera*". In it Dr. Matthew has separated the plants of this formation from those taken from Gaspé and other Devonian localities, to show the special types that characterize the Little River Group. Thus isolated, they are seen to have a facies remarkably like that of the usual groupings of Coal-measure plants, with which they have been confounded by several specialists. But in this case the stratigraphy, Dr. Matthew asserts, shows that they must be much older than the Carboniferous age. He claims that the genera *Pseudobaiera*, *Ramicalamus*, *Lepidocalamus*, and *Ginkgophyton* are not known in strata more recent than the Little River Group; the first and last of these genera are Pteridosperms, while the other two belong to the Equisetaceæ. Certain filicoid genera are also common in this group—*Aneimites*, *Neuropteris*, *Pecopteris*, *Megaphyton*, etc. *Psilophyton* occurs, but not the typical forms described by Dawson from the Devonian of Gaspé, etc.

A revised list of the species of plants of the Little River Group described by Sir William Dawson is given, together with notes on the several species, and quite a number are claimed to be Pteridosperms on the basis of their resemblance to Carboniferous filicoid genera that have been shown to be seed-bearing.

The closing part of the article is devoted to a redescription of *Pseudobaiera* as represented by *P. McIntoshi*. Additional material has been obtained which shows more fully both the vegetative and fruiting branches or shoots; the former are more typically filicoid than those first obtained, and the latter show examples of the mature as well as the young fruit or fruit pods.

Even with the plants of the Little River Group excised the Devonian flora of Eastern North America shows no less than forty species, mostly described by Sir William Dawson, and furnished by localities extending from Pennsylvania to Gaspé. *Psilophyton*, *Lepidodendron* (with small areoles), and *Archæopteris* are genera which are most markedly characteristic of the Devonian age.

IV.—Draysoniana: being an attempt to explain and popularise the system of the second rotation of the earth as discovered by the late Major-General A. W. Drayson, F.R.A.S. By Admiral Sir Algernon F. R. De Horsey, K.C.B. 8vo; pp. ix, 76, with numerous diagrams. London: Longmans, Green, & Co., 1911. Price 3*s.* 6*d.* net.

IN 1871 Drayson read before the Geological Society a paper "On the probable Cause, Date, and Duration of the Glacial Epoch of Geology". This was published in abstract, and the author concluded that "about 21,000 years ago the climate would become more and more extreme up to about 15,000 years ago, and then gradually more and more equable to about 6,000 years ago". These estimates appear to have undergone subsequent revision, as Admiral De Horsey remarks (p. 69) "that among the results of Drayson's discovery is the geometrical proof that the glacial period lasted only about 16,000 or 18,000 years, and terminated about 7,500 years ago". It is not right to say that "nearly all geologists in America and England have from geological evidence found that the dates given by General Drayson about thirty years ago were absolutely accurate". Prestwich's estimates of 1887 agree approximately with those of Drayson, and it is true that there has been a disposition to adopt lesser estimates for the duration of the Glacial epoch than those of thirty or forty years ago. *Draysoniana* deals mainly with matters astronomical.

V.—Brief Notices.

1. St. Albans and its Neighbourhood.—Under this title the Hertfordshire Natural History Society has reprinted from its Transactions and issued as a pamphlet (price 2*s.* net, Dulau & Co., 1911), a report that had been specially compiled by members of the Society for use during the Sixteenth Annual Congress of the South-Eastern Union of Scientific Societies. The report contains an account of the Topography, Geology, Hydrology, Climate, Flora, Fauna, and Archæology of the district, with a guide to the Hertfordshire County Museum. It is edited by Mr. John Hopkinson, who has contributed a concise account of the geology, as well as several other articles, the area described being a radius of 5 miles from the Town Hall at St. Albans. The work is accompanied by several topographical maps and pictorial views.

2. In a pamphlet entitled *The Stone Age and Lake Lothing* (Norwich, Norfolk News Co., 1911), Mr. J. Chambers describes an excavation made recently in the bed of the channel which lies between Oulton Broad and Lowestoft Harbour. The section showed, beneath the harbour mud, "a bed of peat about 2 feet thick. Below this about 5 feet of sand. In the middle of this sand was a layer of vegetable-looking mould 1½ inches thick. On this were roots of bushes, the branches of which, well-preserved, penetrated the sand above. These roots would be 4 to 6 feet below low-water mark. Below the sand was a bed of coarse gravel 2 or 3 feet in thickness, in which flint implements were found. And below this was sand like that of the sea shore." The implements are not figured, and they appear to be

simply chipped flints. The author mentions that he has "found some in the Crag, London Clay, Reading Beds, and in the Chalk below them". From his descriptions we can form no opinion with regard to the particular flints found in Lake Lothing. Great part of the pamphlet is taken up with a discussion on topographic changes and the etymology of local names.

3. At the meeting of the Lake Superior Mining Institute, held on August 22, 1911, a paper on "A Diamond Drill Core-Section of the Mesabi Rocks", in Minnesota, was read by Professor N. H. Winchell, of Minneapolis.

In the Proceedings of the Institute for the years 1908–10 the author presented evidence to show that in Minnesota volcanic igneous rock composes a large proportion of the strata usually termed 'Animikie', which also specifically may be designated *Mesabi*.

In 1899, towards the close of the Minnesota Geological Survey, some evidence of the nature of the iron-bearing rocks of the Mesabi range was met with, and it was presented in the final report (vol. v), where its purport was fully set forth. It was suggested that if a careful examination were to be made of the rocks of the Animikie, it might be found that detritus from igneous rocks was an important element in their composition. Reviewing what he wrote twelve years ago as to the igneous nature of the rock from which the Mesabi ore was derived, the author expresses satisfaction with the conclusions to which he then came, and now reaffirms and strengthens them, with the new evidence.

4. A New Method of Coast Surveying is described by Dr. John Ball (Ministry of Finance, Egypt: Survey Departmental Paper, No. 21, 1911). The plan is to determine by triangulation the position of a relatively small number of stations on mountains or hills near the coast, and then by means of a theodolite and observation of the direction and depression angle to fix the position of sundry points on the coast. The necessary complex computations have been so far modified by the author that he has been able to make rapid progress with surveys, and he gives full particulars of his new method in the present work.

OBITUARY.

EDWARD WHYMPER, F.R.S.E., F.R.G.S.

Born April 27, 1840. Died September 16, 1911.

We regret to announce the death of this well-known mountaineer, author, and explorer, on September 16, at Chamonix, in the midst of the peaks, passes, and glaciers with which, for more than fifty years, he had been so familiar and had so vividly portrayed in his sketches and descriptions. In early life Edward Whymper was for many years associated with his father and brother in Lambeth as one of the well-known firm of Whymper and Sons, wood-engravers, who flourished as high-class book illustrators in the pre-process and pre-photographic hand-camera days, when the artists for *Punch*, the *Illustrated London News*, and other papers and journals drew their pictures *direct* upon the blocks on which they were afterwards engraved; the drawings and engravings being both extensively carried out by the Whympers, father and sons, assisted by a numerous staff of wood-engravers working under their personal superintendence and instruction. The introduction of process-engraving and the rapid and less costly methods of photo-processes of all kinds have, to a very great extent, swept away the engraver and his art, and they only survive in the illustrations to such luxurious works as are but little known save to the wealthy dilettanti who desire to maintain the now almost extinct wood-engraver's art.

In 1860 Edward Whymper commenced his career as an Alpine climber, and took a commission from a London publisher to make some sketches of the great Alpine peaks. "At this time," wrote Mr. Whymper afterwards, "I had only a literary acquaintance with mountaineering, and had not even seen—much less set foot upon—a mountain. Amongst the peaks which were upon my list was Mont Pelvoux in Dauphiné. The sketches that were required of it were to celebrate the triumph of some Englishmen who intended to make its ascent. They came, they saw, but they did not conquer. By a mere chance I fell in with a very agreeable Frenchman who accompanied this party, and was pressed by him to return to the assault. In 1861 we did so with my friend Macdonald [Mr. Reginald J. S. Macdonald] and we conquered. This was the origin of my *Scrambles amongst the Alps*." In those days Alpine climbing as a sporting pastime was only just beginning to come into vogue. Mr. Whymper fell a willing victim to its fascinations. He had been attracted to Mont Pelvoux by those mysterious impulses which impel men to peer into the unknown. He next set himself to conquer the Matterhorn, which was then regarded as wellnigh insurmountable, and which appealed to him by its grandeur. Repeated failure to scale its summit only stimulated the young enthusiast to fresh endeavours, and the history of these efforts occupies a large part of his first book, *Scrambles amongst the Alps in the years 1860–69*, which first appeared in 1871. Mr. Whymper's perseverance was crowned with success in July, 1865, but the triumph was marred by a terrible disaster. The ascent of the Matterhorn is not now considered as one of unusual difficulty or danger, but the great peak avenged itself on those who first violated its virgin summit by taking a heavy toll for their achievement. On that occasion the summit had been attained, and the descent was in progress, when one of the party lost his foothold, and falling against Croz, the leading guide, knocked him over; the two following members were dragged from their steps; the guide who followed next with Whymper endeavoured in vain to save them by planting themselves as firmly as the rocks would permit, but the rope broke midway between Lord Francis Douglas and the guide Taugwalder, and the four leading members of the party fell down the almost precipitous wall of rock to the Matterhorngletscher below, a distance of nearly 4,000 feet.

During thesey ears of *Scrambles amongst the Alps* Mr. Whymper paid two visits to Greenland, in 1867 and again in 1872. No Alpine peaks tempted him there, but at the instance of Mr. R. H. Scott, F.R.S., and entrusted with a grant from the British Association, he undertook to explore the Tertiary Leaf-beds and Coal-seams at Atanekerdluk, North Greenland, and he not only made sketches and photographs of the cliffs, but brought home a large collection of plant-remains. which was afterwards described by Professor Oswald Heer, of Zurich,[1] a part of that collection, and also the result of his later visit in 1872, being preserved in the Geological Department of the British Museum.[2]

But the achievement which brought him distinction as an explorer and gained for him the Patron's Medal of the Royal Geographical Society was an expedition in 1879–80 to Ecuador, where he made important ascents and investigations among the Great Andes of the Equator. Early in January, 1880, he attained the summit of Chimborazo, 20,498 feet, this being the highest climb hitherto placed to the credit of any mountaineer. He was accompanied by two Piedmontese guides, and camps were established at heights of 14,375 feet, 16,624 feet, and 17,285 feet. One of the guides was badly frostbitten, and all the members of the party suffered much inconvenience from mountain sickness. When, however, a second ascent of Chimborazo was successfully accomplished six months later no ill effects were felt from this cause. Nor were the climbers affected by mountain sickness when they scaled the volcano Cotopaxi, 19,613 feet high, though Mr. Whymper stayed for twenty-six hours near the crater in order to experience in his own person the action of the rarefied atmosphere on the human system. In this case, however, he and the guides were not weakened by having to contend against snow and frost, the ground on which they camped at the summit being so hot as almost to melt the indiarubber covering of their tent. The results of these researches were published in *Travels amongst the Great Andes of the Equator* (3 vols., 1891–2).

Climbers among the Alps in later years will remember Mr. Whymper by his two guide-books to Chamonix and Mont Blanc, the former of which reached this year its sixteenth edition and the latter its fifteenth edition.

For years he was well known at home as a lecturer on Alpine subjects, but even so lately as 1901–5 he explored and ascended the mountains of the 'Great Divide', the water-parting of the Rockies, where the primitive sources of the mountain streams separate, the western to join the Columbia River and the Fraser, and so ultimately reaching the Pacific, while the eastern add their contributions to the Bow River, which finally empties into Hudson's Bay. Here on Mount Field (5,000 feet) on the right bank, and Mount Stephen (8,000 feet) on the left bank, Mr. Whymper found Trilobites in the

[1] See Oswald Heer, "Contributions to the Fossil Flora of North Greenland, being a description of the plants collected by Mr. Edward Whymper during the summer of 1867": Phil. Trans. Roy. Soc., vol. clix, pt. ii, p. 445, 1870.

[2] See also Professor Nordenskiöld's "Expedition to Greenland": GEOL. MAG., Vol. IX, p. 419, 1872.

greatest abundance in shales of Middle Cambrian age forming the summit of Mount Field and resting on the flanks of Mount Stephen about 6,580 feet up; the 2,000 feet above the Trilobite shales have not yet been examined.

I gave an account of the fossils brought home by Mr. Whymper, with seven text-figures and Plate XXII in the Geological Magazine, 1902, pp. 502 and 529, and the collections made by him were subsequently presented to the Geological Department of the British Museum (Nat. Hist.). He was a keen observer and collector, and had Natural History been early instilled into his receptive mind he would have been a great Naturalist as well as a great Mountaineer.

[Taken in part from the *Morning Post*, September 18, 1911, the remainder by H. W.]

PROFESSOR PAUL BOGUSLAV RICHTER.

Born 1854. Died October 9, 1911.

This eminent geologist of the Imperial Gymnasium at Quedlinburg, Germany, passed away on October 9, 1911, in his 57th year, deeply regretted.

Professor A. G. Nathorst, of Stockholm, writes us—"Palæobotanists had anticipated that Professor Richter might have lived many years to publish further important contributions to our knowledge of the Keuper Flora of Thale and the Cretaceous Flora of Quedlinburg, both of which he had studied for many years, and of which he had made such extensive and excellent collections.

"In addition to his minor contributions to Palæobotany he published—

1. In 1905, 'Beiträge zur Flora der oberen Kreide, Quedlinburgs.' Teil i: 'Die Gattung *Credneria* und einige seltnere Pflanzenreste.' With six folio plates.
2. In 1906, 'Beiträge zur Flora der unteren Kreide, Quedlinburgs.' Teil i: 'Die Gattung *Hausmannia*, Dunker, und einige seltnere Pflanzenreste.' With seven folio plates.
3. In 1909, 'Beiträge zur Flora der unteren Kreide, Quedlinburgs.' Teil ii: 'Die Gattung *Nathorstiana*.'
4. 'P. Richter und *Cylindrites spongioides* des Goeppert.' With six folio plates."

JOHN GRIFFITHS.

The death is announced (in *Nature*) of Mr. John Griffiths, the well-known fossil-collector of Folkestone. He rendered important service to Mr. F. G. Hilton Price, Mr. C. E. De Rance, and Mr. J. Starkie Gardner in their researches on the Gault and associated formations, and he discovered a large proportion of the most important Gault fossils now in the British Museum and the Museum of Practical Geology. So long ago as 1887 it was announced in the Geological Magazine (p. 140) that Griffiths had been permanently disabled by rheumatism.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VIII.

No. XII.—DECEMBER, 1911.

ORIGINAL ARTICLES.

I.—The British Fossil Shrews.

By Martin A. C. Hinton.

(PLATE XXV.)

REMAINS of Shrews have long been known to occur in the Norfolk 'Forest Bed', and have been discovered in several British Pleistocene deposits. Hitherto they have been referred to one or other of the three species at present inhabiting this country, but having had occasion lately to examine nearly all the available material, comprising representative series of specimens from each of the known horizons, I find that it is not until we reach the latest Pleistocene deposits that we meet with remains of species indistinguishable, with the material before us, from the living British forms.

The Shrews are low Placentals specialized in two ways, viz., (1) for an insectivorous diet, and (2) to a smaller degree for a subterranean existence. They have been divided into two groups:[1] *Soricinæ*, in which the teeth are more or less extensively stained with a reddish-brown pigment; *Crocidurinæ*, in which the teeth are quite white. All the British species, fossil and recent, so far discovered belong to the first group; and so far as the characters of the fossil forms are known they are all referable to one or other of the two living British genera, *Sorex* and *Neomys.*

Sorex stands on a slightly lower plane than *Neomys* in most respects.[2] It retains one more premolar above; in the large lower incisor three or four of the denticles primitively present upon the crowns of mammalian incisors persist until an advanced stage of wear has been reached[3]; and the condyle of the lower jaw and the glenoid articulation of the skull, although differing much from the normal mammalian type, are a little less highly modified. In the small size of most of the species, their external characters, and the form of the skull and humerus, we see the effects of an adaptation to life underground.

[1] Dobson, Proc. Zool. Soc., 1890, p. 49. Winge suggested this classification many years before (*Vidensk. Med. Nat. Foren. Kjöbenhavn*, 1877, p. 138).

[2] The best account of the skull of the Shrews and of their relationships is to be found in the following works of Winge: "Om Muldvarpens og Spidsmusenes Cranier og Spidsmusenes systematiske Stilling," *Vidensk. Med. Nat. Foren. Kjöbenhavn*, 1877, p. 115; "Om Græske Pattedyr," ibid., 1881 (1882), p. 12; "Pattedyr," *Danmarks Fauna*, 1908, pp. 14–16, 22–7.

[3] Owen, *Anatomy of Vertebrates*, vol. iii, p. 306, 1868.

Neomys has gone a little further, and, in adopting an aquatic habitat, in a different direction, which has to some extent influenced its external characters. A premolar has been lost above; the large lower incisor has been simplified—only one of the primitive denticles, in addition to that forming the point of the tooth, persisting; and the peculiar modification of the mandibular condyle, and the glenoid cup into which it fits, has proceeded further.

The mandible offers good characters for the determination of the fossil species, and of the earlier British forms little more is known. The strange features presented by the articulation of the lower jaw with the skull in the Shrews were first described by Cuvier,[1] and more fully by Winge[2] and Parker.[3] The mandibular condyle bears two facettes, an upper and a lower, widely separated by a non-articular tract of bone, and which correspond with two facettes upon the squamosal. In *Sorex* (Figs. 7*a*–14*a*) the middle non-articular region is as broad as, or broader than, the superior facette, and the lower facette is not prolonged lingually. In *Neomys* the non-articular region is much narrowed, so that it appears on the posterior view of the condyle as a slender rod of bone connecting the two facettes, the lower facette having in addition a great lingual prolongation (Figs. 1*a*–4*a*). In *Sorex* the *foramen ovale* passes forward between the squamosal and alisphenoid, its mouth, wholly concealed by a process of the squamosal, lying internally to and a little below the lower glenoid facette.[4] In *Neomys* the lingual extension of the lower glenoid facette prevents the *foramen ovale* from opening so far forwards; it therefore has its mouth behind the glenoid cup, and is completely visible on the lower view of the skull.[5]

Sorex.

Dental formula: i. $\frac{1.2.3}{1}$ c. $\frac{1}{1}$ p. $\frac{4.3.1}{1}$ m. $\frac{1.2.3}{1.2.3}$ = 32.[6] Lower incisor with three or four long persistent denticles. Middle non-articular part of condyle not reduced in breadth, lower condylar

[1] Cuvier, *Leçons d'Anatomie Comparée*, 2nd ed., t. ii, p. 323, 1837.

[2] Winge, *Vidensk. Med. Nat. Foren. Kjöbenhavn*, 1877, pp. 119, 121, etc.

[3] Parker, "On the Structure and Development of the Mammalian Skull."—Part III, Insectivora: Phil. Trans., pt. i, pp. 213–15, pl. xxxi, figs. 3, 3*a*, 10, *cd.p.*, *gl.c.*, 1885.

[4] Parker, op. cit., p. 217, pl. xxxi, figs. 2, 3.

[5] Winge, op. cit., p. 134, fig. 6; Parker, op. cit., p. 217.

[6] Notwithstanding the fact observed by E. Brandt, viz. that the premaxilla holds *four* teeth, I prefer to follow Winge and regard the last of these teeth as the canine, and not as inc. $\frac{4}{}$—a tooth quite unknown among Placentalia. The premaxilla has grown that it may accommodate the enlarged first incisor, and in so doing it has embraced the vestigial canine. There is nothing more remarkable in this than there is in the fact that the upper incisor of most rodents bursts through the premaxilla behind and attains a seat in the maxilla. The transgression in either case receives a physiological explanation (see Winge, "Jordfundne og Nulevende Pungdyr fra Lagoa Santa," *E Museo Lundi*, ii (11), p. 122, Anm. 39, 1893; *Vidensk. Med. Nat. Foren. Kjöbenhavn*, 1881, pp. 12, 13, and 1882, p. 65). I also prefer to write the premolar formula in Hensel's way ("Ueber Hipparion Mediterraneum," *Abhand. königl. Akad. Wiss. Berlin*, 1860, p. 78). From the excessive reduction of the tooth here called p. $\frac{3}{}$ we may infer that the missing tooth in *Sorex* is p. $\frac{2}{}$.

facette without lingual prolongation, *foramen ovale* not visible on lower view of skull.

The genus occurs in the Forest Bed and later British deposits. With the exception of *S. savini* all the fossil species are small, forms not exceeding *S. araneus* in size.

SOREX SAVINI, n.sp. (Pl. XXV, Figs. 6, 7, and Text-fig. 7*a*.)

Sorex remifer, Owen, *British Fossil Mammals*, 1846, p. 28, fig. 14, No. 3.
S. vulgaris, Newton, *Vertebrata Forest Bed*, 1882, p. 97, pl. xv, figs. 5–8; Woodward & Sherborn, *Cat. Brit. Foss. Vert.*, 1890, p. 382.
" *Sorex*, large species " Newton, op. cit., p. 97, pl. xv, figs. 13, 14.
Crossopus remifer, Lydekker, *Cat. Foss. Mam. B.M.*, pt. i, p. 17, 1885.

[While this paper has been passing through the press the names of the new species (herein fully described for the first time) have been published in Barrett Hamilton's *History of British Mammals*, parts viii and ix, September and November, 1911, pp. 80, 125.]

Material examined.—(1) Two mandibular rami, left and right, the latter the specimen figured by Owen (loc. cit. sup.) from the Upper Freshwater Bed at Ostend (Green Coll., B.M., Nos. 17653 and 15949*a*); (2) two right rami and two fragmentary maxillæ, figured by Newton (loc. cit. sup., pl. xv, figs. 5–8), in the Museum of Practical Geology; (3) seven rami (five with posterior end) and several maxillæ in the Savin Coll. (B.M. 6154 and 6157); (4) fifty-four rami (thirty-eight with posterior end) and several maxillæ in Mr. Savin's private collection; (5) posterior part of a right ramus in my own collection; in addition numerous limb-bones. Excepting the specimens in the Green Collection the whole of this material was obtained from the Upper Freshwater Bed at West Runton.

Characters.—Size large (the dimensions of the remains of this and other species are given in the tables of measurements at the end). Mandible (Figs. 6, 7, 7*a*): coronoid process large and stout, its upper border broad and round, its outer surface having posteriorly a well-marked and extensive fossa for insertion of the tendon of the lower part of the temporal muscle and fibres from the separate horizontal muscular band which runs below the temporal; condyle very massive. Teeth stained deeply from summit to external cingulum; the latter well developed. Incisor (seen in seven jaws) as in recent *Sorex*, with four denticles and three notches in moderately worn specimens—the two posterior notches are the deeper ones. Skull: known at present only from maxillary fragments; posterior border of infra-orbital canal above front edge of m. $\frac{1}{}$; lachrymal foramen over middle of m. $\frac{1}{}$. Two specimens (S.C. B.M. 6157 and S.C. 637.5)[1] show that there were five unicuspid teeth as in recent *Sorex*. Two specimens (S.C. B.M. 6157 and S.C. 637.7) have the three posterior unicuspids in place and one or more are seen in several other fragments. The unicuspids decrease in size regularly from before backwards as in *S. minutus* and *S. alpinus*; p. $\frac{4}{}$ projects beyond cingulum of p. $\frac{1}{}$, it is entirely visible externally and, although

[1] 'S.C. B.M.' means 'Savin Collection, British Museum'; 'S.C.' means the more recently formed private collection of Mr. Savin.

shorter antero-posteriorly, a little wider than either p. $\frac{4}{\ }$ or the canine. Cheek-teeth (p. $\frac{1}{\ }$–m. $\frac{3}{\ }$) essentially as in recent *Sorex*; posterior emarginations of first three (p. $\frac{1}{\ }$–m. $\frac{2}{\ }$) considerably shallower than in *S. araneus*—a feature well seen in Newton's figures (op. cit., pl. xv, figs. 5, 6).

The larger limb-bones from the Forest Bed are clearly referable to *S. savini*. The humerus (five complete examples before me) differs importantly from that of *S. araneus* in that the ridges for the insertion of the pectoral, deltoid, and *teres major* muscles descend to a much lower point upon the shaft (*vide* Newton's figure, op. cit., pl. xv, fig. 14). Length of humerus, 9.2–10.1 mm.

Remarks.—Science owes much to Mr. Savin's careful collecting from the Forest Bed, and personally I am indebted to him for the extreme liberality with which he has placed his material at my disposal. I have therefore great pleasure in naming this fine Forest Bed species in his honour. *S. savini* is distinguished as the largest British Shrew hitherto discovered, and it is only known from the Upper Freshwater Bed.

Sorex runtonensis, n.sp. (Pl. XXV, Figs. 8, 9, and Text-fig. 8*a*.)

Crossopus fodiens, Owen, *Brit. Foss. Mam.*, 1846, p. 28, fig. 14, No. 1; Lydekker, *Cat. Foss. Mam. B.M.*, pt. i, p. 17, 1885.
Sorex pygmæus, Newton (in part), *Vert. For. Bed*, p. 97, pl. xv, fig. 11, 1882.

Material examined.—Mandibulæ: (1) two left rami from Upper Freshwater Bed, Ostend (Green Coll., B.M. 17653*a* and 15949), the first specimen being that figured by Owen (loc. cit. sup.) and referred by him to *Crossopus fodiens*—the characters of the condyle and incisor clearly show it to be referable to *Sorex* and not *Neomys*; (2) two rami in the Museum of Practical Geology, of which one was figured by Newton (loc. cit. sup.); (3) a left ramus in Savin Coll. (B.M. 6154); (4) thirty-two rami in Mr. Savin's private collection. All the specimens enumerated have either the condyle or else the incisor in place; all come from the Upper Freshwater Bed, and, excepting the two in the Green Collection, from West Runton.

Characters.—Size small, but considerably larger than *S. minutus*. Mandible (Figs. 8, 8*a*, 9): coronoid process slender and pointed above; condyle very light, its vertical diameter conspicuously less than the antero-posterior length of ascending ramus at level of molars. Incisor when unworn with four denticles and three notches, the two posterior notches persisting until an advanced stage of wear. Teeth stained extensively.

Remarks.—When determining remains of Shrews from the Forest Bed there cannot be any confusion between those appertaining to the species here named *S. runtonensis* and those of the far larger and very different *S. savini*. In size the lower jaw of *S. runtonensis* is intermediate between those of *S. araneus* and *S. minutus*, and it is distinguished from either by the form of the coronoid process, condyle, etc., as will be best appreciated from the figures and measurements. *S. runtonensis* is known only from the Upper Freshwater Bed.

SOREX sp. (Pl. XXV, Fig. 10, and Text-fig. 10*a*.)

Sorex vulgaris, Hinton & Kennard (in part), *Essex Naturalist*, vol. xi, p. 349, 1900.

Among the Shrew remains collected by Mr. Kennard and the writer from the Middle Terrace brickearth of Grays Thurrock are a posterior half of a left ramus, several still more fragmentary rami, and some imperfect humeri of a species of *Sorex*. In size this Middle Terrace form is smaller than *S. araneus*, the difference being quite noticeable in the lower jaw and still more marked in the humeri. The posterior end of the jaw (Figs. 10, 10*a*) offers some differences in the form of the coronoid process and condyle. The fossa for the insertion of the lower part of the temporal muscle, etc., on the outer surface of coronoid process, is absolutely larger than it is in the bigger jaw of *S. araneus*; the superior articular facette is reduced transversely. The teeth have a weak cingulum externally; the staining appears to have been quite weak because little trace of it can be seen in the only moderately worn teeth of the figured specimen, although the colour is well preserved in the teeth of the species of *Neomys* occurring in the same deposit.

I have no doubt that this Middle Terrace Shrew is distinct specifically from any of the other forms described in this paper. I refrain from naming it because the material is so scanty.

SOREX KENNARDI, n.sp. (Pl. XXV, Fig. 11, and Text-fig. 11*a*.)

Material examined.—Anterior part of a skull and both mandibular rami of one individual from the Third Terrace drift of the Lea Valley at Ponders End, Middlesex.

Characters.—Size distinctly smaller than *S. araneus*, larger than *S. minutus*. Apart from its smaller size there is little to distinguish what is left of the skull from that of *S. araneus*; the mesopterygoid fossa is proportionately broader, and does not narrow behind. The incisors and unicuspids have unfortunately dropped out, but the alveoli show that the latter were five in number, and, apparently, that they decreased in size regularly from before backwards as in *S. alpinus* and *S. minutus*, and not in rough pairs as in *S. araneus*. The cheek-teeth, p. $\frac{1}{}$ – m. $\frac{2}{}$, have the posterior emargination less deep than in *S. araneus*. The mandible (Figs. 11, 11*a*) is distinguished by its form and size; condyle agrees better with *S. minutus* and *S. alpinus* in form than with *S. araneus*.

Remarks.—We owe the discovery of the specimen here described to the keen eye of Mr. A. S. Kennard, who obtained it on the occasion of a visit of the Geologists' Association to the very important section at Ponders End.[1] I am unable to refer it to any known species, and have great pleasure in naming this form after my friend, to whom I am indebted in so many ways.

[1] Warren, *Nature*, vol. lxxxv, p. 206, 1910; Proc. Geol. Assoc., vol. xxii, p. 168, 1911.

Sorex araneus, Linn. (Pl. XXV, Fig. 12, and Text-fig. 12*a*.)

Sorex araneus, Linnæus, *Systema Natura*, x, 53, 1758.

S. vulgaris, Linnæus and most recent authors; Woodward & Sherborn, *Cat. Brit. Foss. Vert.*, 1890, p. 382 (Kent's Hole and Teesdale Caverns; material not seen by me); Newton, Q.J.G.S., vol. 1, p. 192, pl. xi, fig. 1, 1894 (Ightham Fissures); Jackson, *Lancashire Naturalist*, 1910 (Dog Holes, Warton Crag).

S. araneus, Dorothea Bate, Geol. Mag., Dec. IV, Vol. VIII, p. 103, 1901 (Wye Cave; material not seen by me).

Material examined.—Fossil: (1) three nearly perfect and more than a score of fragmentary skulls and numerous mandibulæ from the Ightham Fissures (in the collections of Dr. Frank Corner and myself); (2) one perfect and several fragmentary skulls and many mandibulæ from the Dog Holes Cave, Warton Crag, in the British Museum (presented by Mr. J. W. Jackson); (3) six fragmentary skulls and a left ramus from the submerged forest at Leasowe (B.M. M. 7593); (4) a left ramus from the Holocene of Worm's Heath (B.M., presented by Mr. R. H. Chandler). I have studied this material with skulls of twenty-eight recent specimens of *S. araneus* in my own collection, from West Wickham and Ightham in Kent, Wanstead, Essex, and West Runton, Norfolk.

Remarks.—Ightham Fissures: The three nearly perfect skulls of which the dimensions are given in Table I are a trifle smaller than are those of recent *S. araneus*, but among the fragmentary specimens there are many larger ones; forty-one mandibulæ were carefully measured (results summarized in Table II), and give a range of variation similar to that of the recent specimens. I am unable to distinguish these remains from *S. araneus*. Dog Holes: The perfect skull is remarkable for the great breadth of brain-case; the lower jaws (twelve measured) agree with those of *S. araneus*. Two others, with lengths of 8·9 and 9·1 mm., may indicate the presence of *S. kennardi* in this cave, but more material is required. Leasowe and Worm's Heath (Holocene): The remains from these deposits are referable to *S. araneus*, and call for no comment.

S. araneus is not known from any deposit in Britain of greater antiquity than the latest part of the Pleistocene period.

Sorex minutus, Linn. (Pl. XXV, Fig. 14, and Text-fig. 14*a*.)

Sorex minutus, Linnæus, *Systema Naturæ*, xii, 73, 1766.

S. pygmæus, Laxmann, *Sibirische Briefe*, lxxii (ed. Schlözer, 1769); Newton, Q.J.G.S., vol. 1, p. 192, pl. xi, fig. 2, 1894 (Ightham Fissures).

Material examined.—Four rami from the Ightham Fissures in the collection of Dr. Frank Corner.

Remarks.—As will be seen from the measurements, these specimens agree in size with the mandibulæ of this species, to which they appear to be referable.

Neomys.

Neomys, Kaup, *System der Europaischen Thierwelt*, vol. i, p. 117, 1829.

Crossopus, Wagler, Oken's *Isis* (Jena), 1832, p. 275, and most subsequent authors.

Dental formula: i. $\frac{1 \,.\, 2 \,.\, 3}{1}$ c. $\frac{1}{1}$ p. $\frac{4 \,.\;\;.\, 1}{1}$ m. $\frac{1 \,.\, 2 \,.\, 3}{1 \,.\, 2 \,.\, 3}$ = 30. Lower incisor with one persistent denticle. Middle non-articular part of condyle reduced in breadth; lower condylar facette with extensive lingual prolongation; *foramen ovale* visible on lower view of shell. The genus is represented in the Upper Pliocene Forest Bed and later British deposits by species none of which exceed the living *N. fodiens* in size.

NEOMYS NEWTONI, n.sp. (Pl. XXV, Fig. 1, and Text-fig. 1*a*.)

Sorex pygmæus, Newton (in part), *Vert. For. Bed*, 1882, p. 97, pl. xv, fig. 12.

Material examined.—Mandibulæ: (1) left ramus in Museum of Practical Geology figured by Newton (loc. cit. sup.); (2) two right rami in British Museum (Savin Coll., M. 6154); (3) twenty-six rami in Mr. Savin's private collection; (4) two in my own collection. All these specimens were obtained from the Upper Freshwater Bed at West Runton; all of them have the condyle and one has the incisor in place.

Characters.—Size smaller than *Neomys fodiens.* Apart from its small size the mandible (Figs. 1, 1*a*) differs in form from that of the living Water Shrew; the coronoid process is relatively lower. The condyle viewed from behind is of extreme form, the non-articular part being greatly reduced in breadth; its superior facette reaches proportionately further back than in *N. fodiens.* The humerus figured by Newton (op. cit., pl. xv, fig. 9) is, in all probability, referable to this form.

Remarks.—I have named this species *N. newtoni* in honour of Mr. E. T. Newton, F.R.S., to whom we owe so much of our knowledge of the Forest Bed vertebrata. The species is known only to occur in the Upper Freshwater Bed, and it does not require any close comparison with other forms.

NEOMYS BROWNI, n.sp. (Pl. XXV, Fig. 2, and Text-fig. 2*a*.)

Sorex ? sp. non det., Lydekker, *Cat. Foss. Mam. B.M.*, pt. i, p. 16, 1885.
S. vulgaris, Hinton & Kennard (in part), *Essex Naturalist*, vol. xi, p. 349, 1900.

Material examined.—Mandibulæ: (1) posterior half of a left ramus from the brickearth of Grays Thurrock (Middle Terrace), in the British Museum (No. 28079, presented by John Brown); (2) part of a right ramus with m. $\overline{\text{1 and 2}}$ in place, from the same deposit, in the Hinton and Kennard Collection.

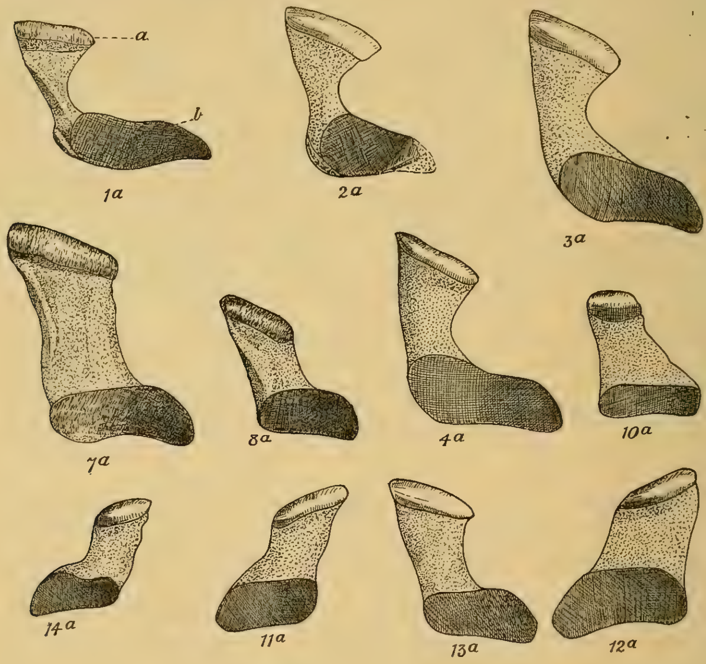
Characters.—Mandible a little smaller than that of *N. fodiens*; its coronoid process low and broad; condyle small, its vertical dimension very small for a *Neomys*, and the superior facette very broad (Figs. 2, 2*a*). Teeth a little smaller than in *N. fodiens*; their outer cusps stained nearly to cingulum; cingulum strongly developed.

Remarks.—This species is named after the late John Brown of Stanway, a careful observer, who discovered and presented the type jaw to the National Collection. *N. browni* is a very distinctive form, recalling *N. newtoni* in the low coronoid process, but differing from all other species in the form of the condyle. It is only known from the Middle Terrace drift of the Thames at Grays.

NEOMYS FODIENS, Schreber.
(Pl. XXV, Figs. 3–5, and Text-figs. 3*a*, 4*a*.)

Sorex fodiens, Schreber, *Die Säugethiere*, vol. iii, p. 571, 1777.
Neomys fodiens, Dorothea Bate, GEOL. MAG., Dec. IV, Vol. VIII, p. 104, 1901 (Wye Cave).

Material examined.—(1) Four mandibular rami (three, including one perfect one, in the Corner Coll., one in Hinton Coll.) from the Ightham Fissures; (2) a left ramus from the Dog Holes Cave, Warton Crag, in the British Museum (presented by Mr. J. W. Jackson); (3) parts of two skulls and a right ramus from the submerged forest of Leasowe (B.M. M. 7593).



Posterior views of condyles of fossil Shrews.

Remarks.—Miss Dorothea Bate has referred "an upper jaw . . . which still retained its full number of teeth", which she found in the Wye Cave, to this species (GEOL. MAG., Dec. IV, Vol. VIII, p. 104). With this exception all the previous records of *Neomys fodiens* in a fossil state in Britain appear to have been founded on error.

Late Pleistocene: Ightham Fissures and Dog Holes. The mandibulæ (Figs. 3, 3*a*, 4, 4*a*) from these deposits have the coronoid process a little lower relatively than in recent jaws of *N. fodiens*, and the condyle appears to be a trifle larger in proportion. They may belong to a distinct form, but with the scanty material before me I should not be justified in separating them from *N. fodiens*.

Holocene: Leasowe. The remains from this deposit agree perfectly with recent *N. fodiens*.

TABLE I. MEASUREMENTS[1] (IN MILLIMETRES) OF SKULLS OF FOSSIL AND RECENT SPECIES OF *SOREX*.

	Sorex araneus.										*Sorex kennardi.*	*Sorex alpinus.* Transylvania. Recent.	*Sorex minutus.* Clevedon. Recent.
	PLEISTOCENE.				RECENT.								
	Ightham Fissures, Corner Collection.			Dog Holes, Warton Crag.	Ightham, Kent.			West Runton, Norfolk.					
	(1)	(2)	(3)		(1)	(2)	(3)	(1)	(2)	(3)			
1. Extreme length to front edge of pre-maxillaries	18·7	18	19·1	18·4	19·0	19·4	19·7	19·1	19·3	19·0	—	19·4	15·3
2. Greatest width of brain-case . . .	8·9	—	—	9·7	9·1	9·8	9·6	9·7	9·7	9·6	—	9·5	7·3
3. Interorbital breadth	3·7	3·6	3·8	3·5	3·7	3·7	3·8	3·8	4·0	3·5	3·2	4·2	2·8
4. Malar breadth	5·28	4·95	5·28	5·17	5·28	5·39	5·39	5·39	5·39	5·39	4·62	5·17	4·07
5. Length of cheek-teeth (i.e. p. $\frac{1}{}$ – m. $\frac{3}{}$)	4·51	4·4	4·62	4·51	4·62	4·62	4·73	4·51	4·62	4·73	4·18	4·4	3·63
6. Length of tooth row, excluding inc. $\frac{1}{}$	6·82	6·6	7·26	6·82	7·26	7·26	7·48	7·26	7·15	7·26	5·94	7·04	5·5
Reduction 1 = 100	100	100	100	100	100	100	100	100	100	100	—	100	100
2 =	47·6	—	—	52·8	47·9	50·6	48·7	50·8	50·3	50·6	—	49	47·7
3 =	19·8	20	19·9	19·0	19·5	19·1	19·3	19·9	20·7	18·5	—	21·7	18·3
4 =	28·2	27·5	27·7	28·1	27·8	27·8	27·4	28·2	27·9	28·4	—	26·6	26·6
5 =	24·1	24·4	24·2	24·6	24·3	23·9	24	23·6	23·9	24·9	—	22·7	23·7
6 =	36·5	36·7	38	37·1	38·2	37·4	38	38	37·1	38·2	—	36·3	36·0

[1] The dimensions 4, 5, and 6 of Table I and all those of Table II, with the exception of the length of the lower jaw, were measured with an eyepiece micrometer and 5 inch objective.

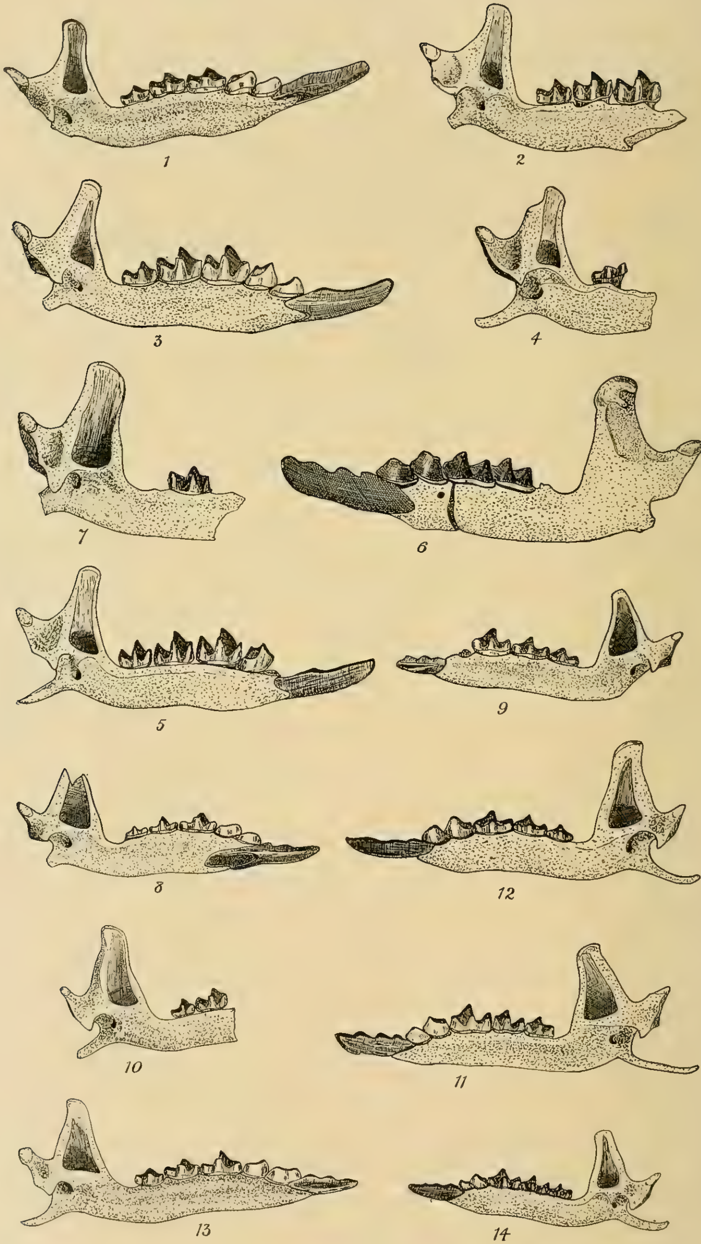
TABLE II. MANDIBULÆ OF FOSSIL AND RECENT SPECIES OF *SOREX* AND *NEOMYS*.

	Length, condyle to most anterior point on bone, inner side.	Length of tooth row, excluding incisor $\overline{1}$.	Length of molars (m. $\overline{1 \text{ to } 3}$).	Height of coronoid process.	Width of coronoid process, condyle to anterior margin.	Height of jaw, inner side, below m. $\overline{2}$.
A. SOREX.						
Sorex savini	11·8	6·05	4·07	5·61	3·74	1·65
	12·0	—	—	5·72	3·85	1·71
S. runtonensis. Fig. 8, Sav. Coll. 731.8 .	9·0	4·73	3·41	—	2·64	1·32
,, Fig. 9, Sav. Coll. 636.15[1]	8·9	4·73	3·74	3·74	2·64	1·21
S. sp. Middle Terrace, Grays	—	—	—	4·4	2·75	1·32
S. kennardi. Third Terrace, Ponders End	9·0	4·78	3·41	3·85	2·64	1·21
S. araneus. Pleistocene, Ightham Fissures	10·3	5·5	3·85	4·84	3·08	1·54
	9·7	5·06	3·52	4·4	2·75	1·48
,, ,, Dog Holes, Warton	10	5·5	3·85	4·4	3·08	1·32
Crag	9·4	5·06	3·57	4·4	2·75	1·32
,, Recent, Ightham	10	5·5	3·85	4·73	3·19	1·48
,, ,, West Wickham . .	10·4	5·5	3·85	4·51	3·08	1·43
	9·7	5·28	3·63	4·51	2·97	1·54
,, ,, Wanstead	9·7	5·28	3·63	4·51	2·97	1·32
,, ,, West Runton . . .	9·9	5·28	3·74	4·62	3·19	1·32
S. alpinus. Hatzeg, Transylvania . . .	10·1	5·39	3·63	3·74	2·64	1·32
S. minutus. Pleistocene, Ightham Fissures	7·6	4·07	2·97	2·97	1·98	0·77
	7·4	4·18	2·97	3·0	2·09	0·77
,, Recent, Clevedon, Somerset .	7·3	4·07	3·13	3·13	2·2	0·99
B. NEOMYS.						
Neomys newtoni. Upper Freshwater Bed, West Runton	10·4	5·61	3·85	4·07	2·86	1·54
N. browni. Middle Terrace, Grays . . .	—	—	4·29	4·29	2·97	1·54
N. fodiens. Pleistocene, Ightham . . .	10·9	6·16	4·4	4·34	2·86	1·37
,, ,, Dog Holes . .	10·1	—	4·29	4·18	2·75	1·43
,, Recent, West Wickham . .	11·0	6·16	4·34	4·56	3·08	1·65
,, *naias*. Recent. Transylvania .	11·4	6·38	4·4	4·73	3·19	1·43

The following scheme shows the range in time in Britain of the various Shrews discussed in this paper:—

HORIZON.		SPECIES.
HOLOCENE		*Sorex araneus*, *S. minutus*, *Neomys fodiens*.
PLEISTOCENE .	*a.* Ightham Fissures, etc.	*Sorex araneus*, *S. minutus*, *Neomys fodiens*.
	b. Third Terrace .	*Sorex kennardi*.
	c. Early Middle Terrace, Grays	*Sorex* sp., *Neomys browni*.
LATEST PLIOCENE	Upper Freshwater Bed (Forest Bed Series)	*Sorex savini*, *S. runtonensis*, *Neomys newtoni*.

[1] This specimen is remarkable for the unusually large true molars.



M. A. C. Hinton del.

JAWS OF BRITISH FOSSIL SHREWS.

It will thus be seen that so far as our knowledge of the fossil Shrews goes they promise to support, when better known, the classification of the Pleistocene deposits which I put forward in my preliminary account of the Voles and Lemmings. *Sorex araneus* and *Neomys fodiens* do not inhabit Ireland, although *S. minutus* is found there. All three were present in Britain in the closing stages of the Pleistocene period; it may be that *S. minutus* arrived a little earlier than its two larger relatives, or it may have been a little better adapted for so adventurous an enterprise as a late Pleistocene journey to Ireland. In conclusion, I have to thank many friends, and in particular Mr. A. C. Savin and Dr. Frank Corner, for much fossil and recent material.

COMBINED EXPLANATION OF LOWER JAWS, PLATE XXV, AND TEXT-FIGURES OF CONDYLES OF SHREWS.

a = superior, *b* = inferior articular facette of mandible.

FIG.

1. *Neomys newtoni*, Hinton. Inner view of left ramus; 1*a*, posterior view of condyle. Upper Freshwater Bed, West Runton. Savin private collection, No. 631.5.
2. *N. browni*, Hinton. Inner view of left ramus; 2*a*, posterior view of condyle. Pleistocene, Grays Thurrock. B.M. 28079.
3. *N. fodiens* (?), Schr. Inner view of left ramus; 3*a*, posterior view of condyle. Pleistocene, Ightham Fissures. Corner Coll.
4. *N. fodiens* (?), Schr. Inner view of left ramus; 4*a*, posterior view of condyle. Pleistocene, Ightham Fissures. Hinton Coll.
5. *N. fodiens* (?), Schr. Inner view of left ramus. Pleistocene, Dog Holes, Warton Crag. B.M., Jackson Collection.
6. *Sorex savini*, Hinton. Outer view of left ramus. Upper Freshwater Bed, West Runton. Savin Pr. Coll., No. 731.10.
7. *S. savini*, Hinton. Inner view of left ramus; 7*a*, posterior view of condyle. Upper Freshwater Bed, West Runton. Hinton Coll.
8. *S. runtonensis*, Hinton. Inner view of left ramus; 8*a*, posterior view of condyle. Upper Freshwater Bed, West Runton. Savin Pr. Coll., No. 731.8.
9. *S. runtonensis*, Hinton. Inner view of right ramus. Upper Freshwater Bed, West Runton. Savin Pr. Coll., No. 636.15.
10. *Sorex* sp. Inner view of left ramus; 10*a*, posterior view of condyle. Pleistocene, Grays Thurrock. Hinton and Kennard Coll.
11. *S. kennardi*, Hinton. Inner view of right ramus; 11*a*, posterior view of condyle. Pleistocene, Ponders End.
12. *S. araneus*, Linn. Inner view of right ramus; 12*a*, posterior view of condyle. Pleistocene, Ightham Fissures. Hinton Coll.
13. *S. alpinus*, Schinz. Inner view of left ramus; 13*a*, posterior view of condyle. Recent, Hatzeg, Transylvania. B.M., No. 3.11.8.12.
14. *S. minutus*, Linn. Inner view of right ramus; 14*a*, posterior view of condyle. Recent, Clevedon, Somerset. Hinton Coll.

II.—The Unconformable Relationship of the Lower Tertiaries and Upper Cretaceous of New Zealand.

By Professor James Park, F.G.S.

WITH the question of conformity or unconformity between the Lower Tertiary and Upper Cretaceous, there is associated a problem of great economic importance to New Zealand. The

[1] Hinton, Proc. Geol. Assoc., vol. xxi, p. 497, 1910.

subject involves something more than a mere academic discussion. If conformity exists, then we have only one coal-bearing formation; but if unconformity, then we have two. I believe that both the stratigraphical and palæontological evidence is overwhelmingly in favour of the latter.

In volume xliii of the Transactions of the New Zealand Institute, Dr. P. Marshall and Messrs. R. Speight and C. A. Cotton in a paper on the "Younger Rock Series of New Zealand" express the view that there is no stratigraphical break from the Cretaceous to the Pliocene, a contention mainly based on their interpretation of the Waipara section in North Canterbury. This section, be it noted, was responsible for the adoption of the Cretaceo-Tertiary theory by the old Geological Survey under Sir James Hector. A better knowledge of the geology of the country showed that this position was untenable. As time went on, and fresh discovery took place, it became more and more evident that the so-called Cretaceo-Tertiary succession consisted of two distinct unconformable series, the one with a distinctively Tertiary fauna, the other with an equally distinctive Cretaceous fauna.

While the theory lasted it led to many incorrect correlations of distant beds. Clayey beds, for example, found below the Ototara Stone were everywhere called Amuri Limestone; greensands containing 20 per cent of living forms were correlated with sandy beds yielding Saurians, Belemnites, etc.; and the term Grey Marls was applied to any grey sandy bed in contact with the Weka Pass Stone.

The confusion introduced by the Cretaceo-Tertiary theory soon became an almost inextricable tangle, on all fours with the famous Cretaceo-Eocene tumble of the Laramie, where it was found that the confusion arose through the erroneous correlation of horizons in distant places, afterwards proved by closer examination to belong to two distinct formations, namely an Upper Cretaceous and a Lower Tertiary.

The time-worn Cretaceo-Tertiary theory of New Zealand was first abandoned by its sponsor, Captain Hutton, then by Professor Cox, and afterwards by myself. For over twenty years it has found no defender or exponent among the field geologists of the country, and, moreover, it was not recognized in the new classification of formations drawn up for the new Geological Survey.

The confusion arose (*a*) through the coincidence that the successions of strata in the Lower Tertiary and Upper Cretaceous formations bear a general lithological resemblance to one another; (*b*) that at Waipara the Tertiary Series seemed to be conformable to the Cretaceous Series.

The Lower Tertiary Series, best known as the Oamaru Series, occurs as a dissected marginal sheet in both islands, while the Cretaceous, or Waipara Series, is restricted to a few isolated patches in each island. The Tertiary Series almost everywhere rests on the highly denuded surfaces of Jurassic or older rocks. In a few places only does it touch the Cretaceous Series.

Both the Tertiary and Cretaceous Series represent a complete cycle of deposition during subsidence, each beginning with fluviatile drifts, with which are associated seams of brown coal, fireclays, and other terrestrial deposits, and ending with a bed of marine limestone.

The Tertiary Series is extensively developed in both islands, and wherever it is found all the members are present from the highest to the lowest bed, except in North Canterbury, where the basal coal beds are absent. Unfortunately there is only one place where all the members of the Cretaceous succession are known to be present, and that is at Waipara.

The succession of the Lower Tertiary Series at Waihao, South Canterbury, which may be taken as typical, and of the Cretaceous Series as seen at Waipara, are shown below in tabulated form:—

Lower Tertiary (Oamaru Series).	Upper Cretaceous (Waipara Series).
1. Limestone (Ototara Stone). Soft coralline, sandy.	1. Limestone (Weka Pass Stone). Hard, crystalline.
2. Greensands, with Tertiary fauna.	2. Grey chalky limestone with Ammonites (Amuri Limestone).
3. Sandy beds and sandstones, with Tertiary marine shells in great abundance, with 20–5 per cent of living species.	3. Greensands, with *Belemnites*, etc.
4. Conglomerate, shales, and brown coal.	4. Sandy beds, with septarian concretions containing Saurian remains, etc.
	5. Conglomerate, shales, and brown coal.

In the days of the Cretaceo-Tertiary theory the Weka Pass Stone was believed to be the equivalent of the Ototara Stone, and this was responsible for much of the confusion, for according to this view the Weka Pass Stone was conformably underlain by beds that in one place contained a purely Cretaceous fauna and in others a purely Tertiary fauna, including a number of living species. It was more puzzling still that the Tertiary facies appeared all over New Zealand while the Cretaceous was confined to a few isolated patches. Moreover, there was never any mingling of the faunas. These anomalies created constant misgivings in the minds of those most wedded to the theory, with the result that many hypotheses were examined and fully discussed by the field-geologists of the Survey, but all were rejected as untenable.

While still in the belief that there was one and not two series, we frankly recognized that we were faced with an apparently insoluble problem in the failure of the Tertiary fauna to invade the few isolated patches occupied by the Waipara Series. The Tertiary fauna had found time to spread from one end of New Zealand to another, therefore slowness of migration could not be entertained as a satisfactory explanation.

I will now examine the evidences of unconformity as presented at Shag Point, Northern Otago, Waipara in North Canterbury, and Komiti Point, North Auckland.

Shag Point District.—In this district we have a good development of both the Lower Tertiary and Cretaceous Series lying side by side in actual juxtaposition. The whole of the Tertiary Series is present from the calcareous sandstone (Waikouaiti or Ototara Stone) down to the basal conglomerates, while all the members of the Cretaceous Series are present except the higher members, namely the Amura Limestone and Weka Pass Stone.

The Cretaceous Series rests on a highly denuded surface of the Palæozoic mica-schist. The Tertiary Series also rests on the mica-schist and abuts against the various members of the Cretaceous Series.

The Tertiary beds extend northward from Waikouaiti to the Shag River, occupying the floor of the Lower Shag Valley, which is wide and low-lying. The beds are nearly horizontal or dip towards the sea at angles between 3° and 5°. Their succession has been determined by bore-holes and outcrop exposures.

The Cretaceous Series forms the steep ridges on the north side of the Lower Shag Valley. Its basal conglomerates and coal-measures are tilted at high angles, and, going eastward to the sea, are folded as shown in Fig. 1.

The upper beds (No. 1) contain *Belemnites lindsayi*, and Saurian bones form the nucleus of many of the septarian boulders, many of which attain a diameter exceeding five feet. Beds No. 2 contain *Conchothyra parasitica*, *Trigonia*, *Rostellaria*. The Cretaceous facies of these beds has never been disputed.

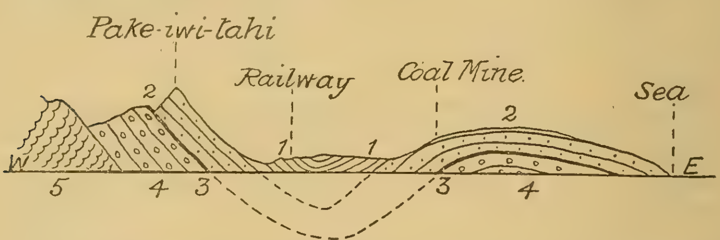


FIG. 1. (1) Dark greensands passing down into shaly clays and sandstones with numerous septarian boulders; (2) brown sandstones alternating with gritstones and pebbly beds; (3) gritstones, loose sands, and grits, with shales and coal-seams; (4) conglomerates, mainly quartzose, passing into mica-schist breccia at base; (5) mica-schist.

The nearly horizontal Tertiary strata, on the other hand, that abut against the tilted and folded Cretaceous Series contain only the typical Lower Tertiary fauna of the Oamaru Series. Moreover, the large septarian concretions that are so characteristic of the Cretaceous beds are absent. The thickness of the tilted and folded Cretaceous strata is 2,200 feet, and of the adjoining horizontal Tertiaries 1,200 feet.

Sir James Hector, in 1862, before the Cretaceo-Tertiary theory was thought of, in a beautiful coloured geological map of North Otago, now in the Otago University School of Mines, showed the horizontal Tertiaries resting unconformably on the Shag Point Cretaceous Series as they are seen to do in the field. This relationship is shown in Fig. 2.

The authors state that the unconformity shown in my section (*Geology of New Zealand*, p. 116) is a matter of inference, as no outcrops could be found in the estuary. This was apparently an oversight on their part as the Tertiary rocks form the low banks of a branch of the Shag River near the mouth, well within the influence of the tidal flow.

The complete succession of the two series is given below—

LOWER TERTIARY.

1. Calcareous sandstone (Ototara Stone).
2. Greensands.
3. Blue clays.
4. Soft dirty-grey sandstones.
5. Quartzose conglomerate, shales, and brown coal.

UPPER CRETACEOUS.

1. Greensands.
2. Shales and sandstones, with septarian concretions.
3. Brown sandstones, gritstones, and pebbly beds.
4. Gritstones, loose sands, and grits with shales and seams of brown coal.
5. Quartzose conglomerates, passing down into breccias. Bed-rock = mica-schist.

The total thickness of the Tertiary basal conglomerate is about 300 feet, and of Cretaceous basal conglomerates about 1,500 feet.

The Cretaceous age of the Shag Point Series has always been admitted, but according to the Cretaceo-Tertiary theory this series is the horizontal equivalent of the adjoining Shag Valley – Waikouaiti

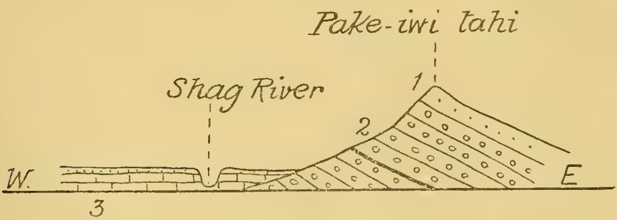


FIG. 2, showing relationship of Lower Tertiaries to Shag Point Cretaceous Series. 1 and 2, Cretaceous beds; 3, calcareous sandstone (Waikouaiti or Ototara Stone), with *Pseudamusium huttoni*, *Meoma crawfordi*, etc., as seen in north bank of Shag River, opposite Pake-iwi-tahi Cairn, where subject to tidal influence.

Series, which contains the typical Lower Tertiary fauna of the Oamaru Series. Here we have the Cretaceous (Waipara) Series and the Lower Tertiary (Oamaru) Series lying side by side. The Cretaceous rests on the mica-schist, and the Tertiary on both the schist and the various members of the Cretaceous.

Professor Cox when a supporter of the Cretaceous theory examined Shag Point, and seeing the difficulty of correlating the two series with one another, suggested the existence of a fault on the north side of the Lower Shag Valley, along the boundary of the two series. Of this fault there is no structural evidence whatever, but, even if it does exist, it merely serves to emphasize the unconformity between the two series, for if the fault is meant to imply that the Tertiary Series followed the Cretaceous Series conformably, and has been merely faulted down into its present position in the Shag Valley, then obviously in the faulted portion we should expect to find the Cretaceous Series underlying the Tertiary Series, but as a matter of fact the Tertiaries rest hard on the mica-schist and wrap round the edges of the Cretaceous.

Mr. A. G. MacDonald, B.E., Government Research Scholar for Otago, has just completed a detailed geological survey of the Shag

Point District. His work of many months in this limited area shows no evidence of faulting, and seems to prove the unconformable relationship of the Cretaceous and Tertiary formations beyond all possible doubt. Moreover, it is almost certain that the tilting and folding of the Cretaceous Series took place before the deposition of the Tertiaries; for it is inconceivable that the younger series could have escaped the folding movement that subjected the older to such sharp disturbance.

Fig. 3. Map of Shag Point.

Kaitangata District.—Here, as at Shag Point, we have both Lower Tertiary and Cretaceous strata, which, according to the Cretaceo-Tertiary theory, are supposed to be horizontal equivalents. The Kaitangata Cretaceous Coal Series rests on the schists, and the Tertiary Series on both the schists and Kaitangata Series. No actual contact of the Cretaceous rocks and Tertiaries is anywhere exposed, the juncture being obscured by a thick sheet of glacial detritus. But the distribution as shown by the very exact mapping lately carried out by Mr. A. G. MacDonald, the marked difference in the character of the strata, and the palæontological evidence seem to leave only one conclusion possible.

The Tertiary sequence is almost identical with that found in other parts of New Zealand, being as follows:—

TERTIARY SERIES.

		Feet.
1.	Limestones	125
2.	Greensands	125
3.	Brown and grey sandstones	460
4.	Quartzose sands, grits, and conglomerates, with seam of brown coal	260

The thickness of the whole series is about 970 feet.

The characteristic fossils of the Upper Oamaruian are abundant, including *Pseudamusium huttoni*, *Cirsotrema browni*, *Meoma crawfordi*, and *Kekenodon onemata*. The Cretaceous rocks are represented by only the lower members of the Waipara Series, as follows:—

1. Sandstones and shales. 2. Greywacke conglomerates, with shales and seams of brown coal, one 35 feet and one 18 feet.	Kaitangata Upper Coal-measures.
3. Brown sandstones and shales. 4. Sandstones, with calcareous layers; fossiliferous. 5. Quartzose sands, bands of conglomerate and shales, with seams of brown coal.	Kaitangata Lower Coal-measures (Castle Hill and Taratu Coals).

The total thickness of these beds is about 1,450 feet, as compared with the 260 feet of the corresponding Coal-measures of the Tertiary Series. Moreover, the great bands of greywacke conglomerate, so conspicuous in the Kaitangatas, are unrepresented in the Tertiary Series.

The Tertiary Series contains only Tertiary forms; but the fossiliferous sandstones of the Kaitangata lower measures contain, among numerous well-preserved fossils, *Belemnites lindsayi*, *Cucullæa alta*, *Conchothyra parasitica*, and *Rostellaria*, forms which connect these beds with the Cretaceous Shag Point and Waipara formations.

Relationship of Waitemata Series to North Auckland Coal Series.—The North Auckland Coal Series consists of the following members:—

1. Sandstones.
2. Hydraulic limestones.
3. Greensands, with septarian boulders.
4. Semi-crystalline limestone.
5. Soft sandstones and shales, with seams of pitch coal.
6. Conglomerates and sandstones.

The septarian concretions that occur in the greensands are covered with an exterior skin of cone-in-cone limestone, and frequently enclose Saurian bones. The Cretaceous age of this series is not in doubt.

The Tertiary Waitemata Series is now acknowledged by all geologists to belong to the Oamaruian, a relationship based on the strongest palæontological grounds.

In my examination of the Auckland district in 1885, I found blocks of the hydraulic limestone in the Lower Waitematas near Howick and Onehunga, and the following year discovered on the coast near Wade a beautiful section showing the Waitemata resting unconformably on the Cretaceous rocks.

At Komiti Point the Tertiary Series contains a large assemblage of fossils, the majority of which are found in the Waitematas, Mount Brown, and Kakanui Beds. When reporting on these beds I placed them in the Upper Eocene,[1] and there is no reason to doubt their relationship to the Waitemata and Oamaru formations. At Komiti Point the Tertiaries rest on the highly denuded edges of the hydraulic limestone, as seen in a very clear section exposed in the sea-cliffs. These observations, it should be noted, merely confirmed the opinion previously expressed by Professor Cox and Mr. McKay that the older Tertiaries were unconformable to the Cretaceous Coal Series.

Waipara District.—In the district there is a complete development of the Cretaceous Series from the Weka Pass Stone down to the basal conglomerates containing brown coal, as under:—

1. Weka Pass Stone.
2. Amuri Limestone, with Ammonites.
3. Greensands.
4. Sand and shaly clays, with septarian boulders containing Saurian remains, *Conchothyra parasitica*, etc.
5. Grits, conglomerates, and shales, with bands of impure brown coal.

The Lower Tertiary Series is well developed, but the lowest member, the Brown Coal-measures, is absent. When viewed in

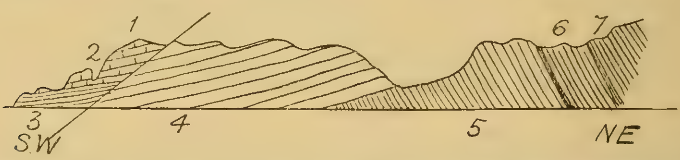


Fig. 4. Section at Komiti Point, showing unconformable relationship of Lower Tertiaries and Cretaceous Coal Series. 1–4, Lower Tertiaries; 5–7, shales and chalky clays passing into hydraulic limestone.

cross-section the Tertiary beds appear to follow the Weka Pass Stone conformably. The members of the Tertiaries present are—

1. Calcareous sandstone bands (Mount Brown or Mount Donald Beds).
2. Greensands.
3. Dirty greyish sandstones.
4. Absent (conglomerate, shales, and brown coal).

The failure at first to recognize the absence of the basal grits and conglomerates of the series arose from the erroneous correlation of the Ototara Stone with the Weka Pass Stone, the Cretaceous Series with its Saurians and other Mesozoic forms being supposed in the old Cretaceo-Tertiary days to be the horizontal equivalent of the Oamaru Tertiary Series.

According to this correlation, the Ototara Stone lay conformably on Cretaceous strata at Waipara, and conformably on Tertiary strata in a hundred other places both north and south of Waipara. Now the Ototara Stone is the most persistent member of the Lower Tertiary Series throughout New Zealand. According to its distance from the old shore-line it is a sandy, sometimes pebbly, calcareous sandstone

[1] Geol. Reports, 1885, pp. 164–9.

that passes into a compact shelly limestone in a few places. It is everywhere fossiliferous generally, and its characteristic fossils from one end of New Zealand to the other are *Pseudamusium huttoni*, which is never known to be absent, *Cirsotrema browni*, and *Meoma crawfordi*.

The Weka Pass Stone, on the other hand, has never yielded any recognizable fossils, the fossils reported to have been found in it by Haast having been, as I showed in 1904 (Trans. N.Z. Inst., vol. xxxvii, p. 545), obtained from blocks of fossiliferous stone that had tumbled down from the overhanging escarpments of the Tertiary beds on Mount Donald, and lodged on the Weka Pass Stone outcrops.

The authors, however, do not follow the old Geological Survey, but correlate the Oamaru Stone with the Amuri Limestone, and the Weka Pass Stone with the Hutchinson Quarry Beds. I may say that the most enthusiastic supporter of the supposed Cretaceo-Tertiary never ventured so far as to correlate the Oamaru Stone with the Amuri Limestone. The Oamaru Stone everywhere contains a large assemblage of Tertiary fossils, and is admitted to overlie conformably beds that contain from 20 to 28 per cent of living forms. How, then, can it be the equivalent of the Amuri Limestone, which has yielded no fossils except an Ammonite, and which, moreover, is admitted by all observers to overlie conformably beds that contain a large assemblage of Mesozoic Saurians, *Belemnites*, *Conchothyra*, etc.? The suggested correlation has no more foundation than, say, the correlation of the Barton Sands of Hampshire with the Lower Chalk of the North and South Downs. Their correlation of the Hutchinson Quarry Beds with the Weka Pass Stone is supported by no evidence or any attempt to analyse the position.

Now the Weka Pass Stone contains no known fossils, whereas the Hutchinson Quarry Beds contain a fauna rich in forms, of which over 40 per cent are present in the Mount Donald or Mount Brown Beds, which overlie the Weka Pass Stone by many hundred feet. Why, then, correlate the Hutchinson Quarry Beds with the Weka Pass Stone, which contains none of the Hutchinson Quarry fossils, when there is an overlying horizon (Mount Donald) in the same section, which contains so many of them?

In 1904[1] and in my work on the *Geology of New Zealand*, 1910, I correlated the Otatara Stone with the Mount Brown and Mount Donald Beds on the grounds that a very large number of the distinctive fossils was common to both horizons. The Oamaru and Waipara districts are separated by 150 miles, and I should not care to assert that any particular bed at Oamaru was deposited on the same time-plane as some particular portion of the Mount Brown Beds, but I think the similarity of the faunas is so striking that there can be little doubt we are dealing with two closely related series.

The following is a list of nineteen of the more abundant fossils in the Ototara Stone at Oamaru and Mount Brown Beds at Waipara,

[1] Park, "Marine Tertiaries of Otago and Canterbury": Trans. N.Z. Inst., vol. xxxvii, pp. 489–550, 1904.

regarding the two calcareous bands at Kakanui as local extensions of the latter:—

OTOTARA STONE, COMMON ALSO TO THE MOUNT BROWN BEDS.

Kekenodon onemata.	*Pseudamusium huttoni.*
Aturia australis.	*Lima paleata.*
Dentalium mantelli.	*Plagiostoma lævigata.*
Scaphella corrugata.	*Cucullæa alta.*
Siphonalia nodosa.	*Venericardia awamoaensis.*
Cirsotrema browni.	*Magellania novara.*
Ostrea angasi.	*M. parki.*
Anomia alectus.	*Terebratula oamarutica.*
Pecten hutchinsoni.	*Meoma crawfordi.*
P. williamsoni.	

About 46 per cent of the faunas are common. Moreover, *Cirsotrema browni*, *Pseudamusium huttoni*, and *Meoma crawfordi* are characteristic of the Ototara Stone horizon from one end of New Zealand to the other.

The Mount Brown Beds at Waipara contain besides these many forms that are only found *below* the Ototara Stone in the Oamaru district. In fact, the Mount Brown fauna is perhaps nearer that of the Wharekuri sands lying below the Ototara Stone than any other horizon in New Zealand, no less than 50 per cent of its fossils being common to both. It would thus happen that in correlating the Mount Brown Beds with the Ototara Stone instead of a lower horizon, as the palæontological evidence would seem to warrant, I have pursued a conservative course.

Discussing the age of the Oamaru Stone, the authors state that they believe it to be Oligocene, a European refinement of age which our present knowledge of the Tertiary faunas does not justify. But let us suppose for the moment that it is Oligocene as suggested. The Oamaru Stone is, they tell us, the equivalent of the Amuri Limestone, which is by all admitted to lie conformably on the greensands and sandy beds containing Mesozoic Saurians, *Belemnites*, etc. Here, then, we get the curious phenomenon of an Oligocene limestone lying conformably on an Upper Cretaceous formation.

In my report on the Wanganui–King County in 1886–7 I stated that there appeared to be a complete succession from the new Pliocene down to the basal conglomerates of the Lower Tertiary Coal Series. No stratigraphical break was recognized in the Tertiary succession. The unconformity which I thought I recognized at Waipara between the Mount Brown and Motanau Beds may not exist, or if it does it may be purely local. In my classification of the Jamger formations adopted in my *Geology of New Zealand* I have recognized only one physical break, namely one between the Oamaru and Waipara Series. Nothing that I have seen since the publication of that work has led me to alter the opinion I then expressed. Moreover, the evidence is overwhelming that we have two great coal-bearing formations in New Zealand, namely—

1. Oamaru Series . . Lower Tertiary.
2. Waipara Series . . Upper Cretaceous.

The authors state that the new Geological Survey under Dr. Bell did not find it practicable to divide the younger rock series into two or more systems. So far as the Lower Tertiaries and Upper Cretaceous are concerned the reason for this is obvious. Of all the areas covered by the Bulletins issued by the new Survey, in the Kaeo district alone (Bulletin No. 8) were the Lower Tertiary and Upper Cretaceous formations present. In their report on this district Dr. Bell and Mr. E. de E. Clarke took particular pains to point out the obscurity of the sections, and after discussing the situation go on to say[1]: "It will be seen that in the Whangaroa subdivision the sum-total favours the view that the Kaeo Series should be divided into an older portion of Mesozoic age and a younger portion of Tertiary age, or, in other words, that a Cretaceo-Tertiary system is not represented."

A classification of the New Zealand formations was drawn up in 1907 for the Geological Survey by Dr. Bell, the Director, Mr. A. McKay, some time Government Geologist, and myself; and although this classification was recognized as a compromise that did not exactly express the views of any one of us on all points, it did not find room for a Cretaceo-Tertiary succession, the Lower Tertiary and Upper Cretaceous being placed in two separate systems, that is in the Oamaru and Waipara systems respectively. Moreover, I have good authority for saying that the present Director, Mr. Percy G. Morgan, does not recognize a Cretaceo-Tertiary system. The fact is that while flagrant unconformity may exist between two formations, places may be found where deceptive physical conformity may exist, as so well shown by Professor Watts in his *Geology*, fig. 153, p. 221.

The differences that exist between the views of Hutton, myself, and others as to the Waipara section cannot be regarded as proof of a complete succession, but are rather suggestive of the difficulty that had to be faced in the interpretation of a section that seemed to be so opposed to the palæontological evidence.

A fine succession of the Upper Cretaceous is exposed at Amuri Bluff, but as no Lower Tertiary rocks are known there the relationship cannot be established between the two systems in that district.

III.—Upper Cretaceous Terebelloids from England.

By Dr. F. A. Bather, M.A., F.R.S., F.G.S., etc.

(*Concluded from p. 487.*)

Tubes without extraneous Building Material.

Davies referred to *Terebella* (?) *lewesiensis* four specimens said by him to be in the J. R. Capron Collection, purchased for the British Museum in 1879. "Two casts from a quarry near Guildford," he wrote, "which admirably show by impression the membranous or horny structure of the tube, bear no indication of the attachment of any foreign substance." The quarry is Cowslip Pit, near Guildford, and the Chalk appears to be Cenomanian, possibly of the *Holaster subglobosus* zone. The two specimens are believed, on the evidence of Davies' labels, to be those now registered A 1574 and A 1575. "These," continues Davies, "may be referred to the same species

[1] J. M. Bell & E. de E. Clarke, "The Geology of the Whangaroa Subdivision": Bulletin No. 8, N.S., p. 58.

upon the evidence of a third fragment from the same quarry, which has precisely the same surface structure, but has also some scales attached and faint impressions of others." There are in the Capron Collection, among the specimens from Cowslip Pit, three other tubes with the same surface structure as A 1574 and A 1575, namely, A 1576, A 1577, and A 1582; but none of these three has any scales attached or any markings that I can identify as impressions of scales. There is no other specimen of the kind from Cowslip Pit, so that I am unable to identify the "third fragment" of Davies. It is possible that he had in mind another specimen, also from the Capron Collection, but labelled "Glynde", Sussex [58253]; since, near one end of this, there are in the chalk a few fish-scales. This specimen was, in fact, labelled "*Terebella lewesiensis*" by Davies, but the evidence that the fish-scales had anything to do with the tube is not convincing.

A fourth specimen was called as witness by Davies because he believed it to retain "deep imprints of the lost scales and bones". This, if it came from Cowslip Pit as alleged, must have been one of the three mentioned above; but there seems no reason for distinguishing any one of those as more deeply marked than the others, nor do the markings on any resemble the imprints of scales. In ordinary specimens of *Terebella lewesiensis* it is quite easy to see the places from which scales or bones have been knocked off, and there is no difficulty in discriminating between such imprints and the surface ornament of the tubes here in question. Tubes like A 1574/5 are quite common in the Cenomanian, and first aroused my curiosity in the *Actinocamax plenus* zone of Chilcomb Pit, near Winchester, some thirty years ago; but I have never seen any in obvious connexion with fish-scales.

The only specimen that seems to me to lend any support to the view of Davies is one to which, oddly enough, he made no reference, although it was before him in the Mantell Collection [B.M. 4129]. This tube is sharply bent so as to form two limbs, one of which seems to sink into the chalk. This limb, 7 cm. long, is flattened out to a diameter of 24 mm., and is covered with scales and small bones. The other limb, which lies on the surface of the block for a length of 10 cm., is rounded, with a diameter of 17 mm.; except for two or three small scales this limb is bare, but its surface presents some irregularly disposed impressions, which may be those of scales or bones. If this specimen be considered without reference to the others, two explanations of its appearance are possible. First, the bare portion may have been buried in the ooze during life, and the protective wall of fish-debris may have been built up round that part alone which projected above the sea-floor. Or secondly, the whole tube may have been furnished with a protective wall, which has been rubbed or washed away from the more exposed limb, but retained on that part of the tube which was longer covered by the matrix. The first explanation would be quite consistent with the habits and structure of some living Tubicola,[1] but scarcely seems to harmonize with what we infer from the other undoubted specimens of *Terebella lewesiensis*. Were this tube normally provided with a 'Vorderbau' and an

[1] See E. Macé, "De la structure du tube des Sabelles": Arch. Zool. Expér., vol. x, Notes, pp. ix–xiv, especially p. x, 1882.

'Innenbau' (to use the expressions of Ehlers), one would expect to find more evidence of the fact in so large a collection. The second explanation presents no serious difficulty, but its correctness could only be estimated by the person who actually found the specimen in the chalk-pit.

It appears, then, that the reference of the naked tubes to *Terebella lewesiensis* rests on quite inadequate proof. Closer examination of these fossils will show that they have characters of their own quite distinct from those of any of the protected tubes.

Although, as every collector of Chalk fossils knows, these naked tubes, or tube-infillings, are quite common, yet there are not many in the national collection. This may, indeed, be due to their very commonness, as well as to the fact that they are generally dismissed as indeterminable 'fucoids'. The following are the only localities and horizons represented:—

Betchworth, Surrey. Albian, Upper Greensand. [A 1638.]
Wetton Vale, Louth, Lincolnshire. Cenomanian, *subglobosus* zone, Totternhoe Stone. [A 1639.]
Glynde, Sussex. Cenomanian, ? *subglobosus* zone. [58253.]
Cowslip Pit, near Guildford, Surrey. Cenomanian, ? *subglobosus* zone. [A 1574–A 1577, A 1582.]

It is clear that none of these specimens is complete. The greatest length attained is 19 cm. [A 1574].

Some of the specimens are fairly straight. This might be expected in the shorter lengths, but it is also rather notably the case in A 1638, with a length of 16·5 cm. Others are bent or slightly sinuous; thus 58253 is bent into two limbs, 5·5 and 6 cm. long, and has a length of 10 cm. along the chord.

In diameter there is not much difference between different parts of the tube, but A 1576 tapers slightly. The section when clearly seen is elliptical, and in the following list both diameters are given: 10 and 5 mm. [A 1582, A 1575]; 15 and 12 mm. [58253]; 15 mm. [A 1574]; 17 mm. [A 1639]; 17 and 12 mm. [A 1577]; 20 mm. [A 1576]; 20 and 17 mm. [A 1638]. The last specimen is from the Upper Greensand, so that, so far as the Cenomanian specimens are concerned, it is clear that their normal maximum diameter is considerably less than that of the fish-debris and plant-debris tubes.

The surface-ornament of these tubes, though faint and often obscure, seems to be of definite character. It may be roughly described as cancellate, since the surface, if viewed from a distance under oblique lighting, shows a number of slight depressions arranged in fairly regular transverse and longitudinal rows. Closer examination suggests that the appearance is due to a system of transverse folds or waves, crossed by larger and less regular longitudinal folds. Both systems of folds are clearly seen in 58253, A 1638, and rather less clearly in A 1582. The longitudinal folds are particularly clear in A 1574 (Fig. 5). The transverse folds are seen plainly in A 1577 and A 1576, and less plainly in A 1575; in these and in most other cases where they are observed the transverse folds seem to run in curves, forming a succession of widely open V's (Fig. 4). In A 1639, however, from the Totternhoe Stone, the transverse folds, so far as seen, go almost straight round the tube. All this ornament is simply a surface appearance; there does not as a rule seem to be any definite tube-wall.

Some specimens, however [e.g. A 1577, A 1582], show, in addition to the cancellar ornament, a fine-grained linear striation crossing the tube at an angle of about 45° (Fig. 4). This seems to be of semi-crystalline nature like the structure usually known as 'beef'. It is presumably due to a physico-chemical action of the supposed gelatinous tube on the surrounding ooze. In A 1582 the striæ run from left downwards to right, but in A 1577 from left upwards to right.

The Upper Greensand specimen [A 1638] is the only one in which I have noted anything suggestive of an original tube-wall. Here in places there seems to be a thin coating of darker, denser, fine-grained (or crypto-crystalline) rock, but it is very indefinite.

The ornament just described forms an additional reason for refusing to assign these tubes to *Terebella lewesiensis* without far more convincing evidence than that adduced by Davies.

What these fossils may be is a different question which would be better discussed by one more fully acquainted with the possible living organisms than I am, and after examination of far more material than is as yet at my disposal.

Specimen A 1638, collected from the Upper Greensand of Betchworth by the donor, Mr. G. E. Dibley, has been referred to by him as "an unusually large Bacculite" (Proc. Geol. Assoc., vol. xxi, p. 485, Aug., 1910). To this conception of the specimen he was doubtless led by the peculiar curvature of the strongly marked transverse folds in some regions. Mr. G. C. Crick, however, does not claim it for this or any other kind of Cephalopod.

These and similar fossils from the Chalk are usually called 'fucoids'. How any imaginable fucoid, or any other form of vegetable growth, can have resulted in a fossil of this description has never been clear to me; but, since Dr. Stopes declines to include them in her Catalogue of Cretaceous Plants, any who still believe in their fucoid nature may be left to argue the matter with her.

It seems quite certain that these fossils represent tubes, which lay on the sea-floor or in the semi-floating ooze of which it consisted, and, either being deserted by the creature that formed them or persisting after its death and decay, were filled with the ooze in which they lay. The tube-wall, it is clear, was of such strength and consistency as to retain its form fairly well during this process, and yet of such composition that it disappeared after the partial consolidation of the ooze. The markings on the infilling of the tube may be due to two causes; either a similar folding of the tube-wall during life, or a wrinkling and contraction of the tube after death and perhaps even after burial. The relative regularity, constancy, and peculiar curvature of the transverse folds suggest that they were originally present in the tube, and that they may have been connected with the ringed structure of the tube-builder. On the other hand, the irregularity and very varying development of the longitudinal folds suggest that they, at least, were due to post-mortem changes.

From the Cretaceous beds of the European Continent, and notably from the Flysch, a large number of supposed fucoids have been described. They were studied and classified in 1897 by Professor A. Rothpletz in his valuable paper "Ueber die Flysch-Fucoiden und einige andere fossile Algen" (Zeitschr. deutsch. Geol. Gesell., vol. xlviii, pp. 854–914, pls. xxii–xxiv). More recently Dr. Otto M. Reis (January, 1910, "Zur Fucoidenfrage," Jahrb. k.k. Geol. Reichsanst., lix, pp. 615–38, pl. xvii) has attempted, and I think with much success, to prove that a number of these Flysch 'fucoids' are the tubes of Terebelloid Tubicola. He seems to regard most of them as having been built up of clay in the same way as the tube of the living *Terebella figulus*. If such genera as *Granularia*, *Squamularia*, and *Keckia* are really based on tubes with a wall capable of being explained in this way, then our specimens are not referable to any of those genera.

For the present the British Museum does not possess enough examples of the numerous strange forms so ably discussed by Rothpletz, Th. Fuchs, O. Reis, and others [1] for any comparison to be made, or for any understanding of the many generic names that have been proposed. To those names I have no intention of adding another.

It has, however, been urged that, for convenience of reference, some name is required for these tubes. Since they have been called '*Terebella*', they may continue to be so called, strictly without prejudice, and may be distinguished as

'*Terebella*' *cancellata*, n.sp. (Pl. XXIV, Figs. 3–5.)

Diagnosis.—Tube from which the (? gelatinous or mucinous) wall has disappeared, leaving on the internal cast an obscure cancellate ornament formed by transverse and longitudinal folds; with diameter from about ·75 to 2 cm., and with a possible length of 19 cm. or more.

Horizon.—Cenomanian, so far as recorded.

Locality.—East and South-East England generally, so far as recorded.

Holotype.—B.M. 58253, from Glynde, Sussex (Fig. 3).

It will be observed that I definitely exclude the Upper Greensand specimen A 1638, which may be known for the present as '*Terebella*' cf. *cancellata*.

Tubes made of Mud Bricks.

Keckia (?) sp. (Pl. XXIV, Fig. 1.)

Associated in the national collection with the series of *Terebella lewesiensis* is another tube labelled "Terebella ?, Chalk. Mantell Colln. [4784.]". This is in a greyish, slightly rust-stained chalk, doubtless of Lower Cenomanian age, from South-East England. The specimen is unlike any other in the Museum.

The tube is 7·2 cm. long, slightly flexuous, with a diameter of about 6·5 mm. It appears to have had a distinct wall (now in part broken away) composed of bricks or tiles fashioned from the chalk ooze and laid in a series of imbricating whorls. A spiral arrangement of the whorls is not to be detected, but each appears to have passed

[1] See references in my note "Some Fossil Annelid Burrows", Geol. Mag., March, 1910, pp. 114–16.

straight round the tube. Whether each whorl was composed of several tiles or only of one, continuous all round, is uncertain. The length of a tile was about 6·5 mm., and of this the distal 3 mm. overlapped the next whorl.

The substance of the tiles does not seem to differ in any definite way from that of either the surrounding matrix or the infilling of the tube. Their surface, however, has occasionally a striated 'beefy' appearance.

It is clear that this fossil accords with the interpretation that Dr. O. Reis has given of the Flysch fossils mentioned above. So far as one can follow the descriptions in the absence of material, it seems to approach most nearly the forms classed by Rothpletz (1897) under *Keckia*. "Hierunter verstehen wir die stielförmigen und dichotom verzweigten Fucoiden, welche in Folge von Quereinschnürungen wie aus einer Reihe von Ringen zusammengesetzt erscheinen. Je nach Erhaltungszustand erscheinen diese Ringwülste auch schuppen- oder scheideförmig. Das Genus ist von [E. F.] Glocker 1840 [i.e. 1844] (Acta Acad. Leop. Carol., xix [Suppl., Bd. ii, p. 319]) für eine Art aus dem Karpathensandstein Mährens . . . aufgestellt worden, die er als [*Keckia*] *annulata* bezeichnete." The chief difficulty lies in the words 'dichotom verzweigten'. Glocker's elaborately coloured plate iv does in fact represent a much-branched structure. Of course, our specimen might be a single branch of a branching tube, but I greatly doubt it. However, for the sake of having a name, it may be left in *Keckia* for the present.

Granularia (?) sp. (Pl. XXIV, Fig. 2.)

A small piece of Gault clay [B.M. 39453], from Folkestone, Kent, 7 cm. by 5·7 cm. in area, is strewn with several fragments of tubes composed of granules or pellets. This was bought from Edward Charlesworth about 1860, and was entered in the register of the Geological Department as "'oviform bodies', qy. worm castings". Of late years it has been placed on exhibition under the generic name "*Sabella* (?)". On the other hand, there can be no doubt that the specimen agrees in general character with several usually regarded as 'fucoids' and placed under some such name as *Granularia*. These facts show that the palæontologists of the British Museum were more than prepared to accept the conclusions so lucidly drawn by Dr. Reis (1910).

The tubes are much like those from the Upper Cretaceous Alberese, figured by Reis (pl. xvii, fig. 1) under the name *Granularia lumbricoides*, Heer; stouter and coarser than those figured by Rothpletz (1897, pl. xxii, figs. 8, 9) under the same name; and most precisely represented by the drawings of *Phymatoderma cœlatum*, Saporta (1873, Paléont. Franç., Plantes Jurassiques, tome i, p. 472, pl. lxviii, figs. 3, 3*a*).

The direction of the tubes is approximately parallel to the shorter axis of the Gault slab. They are in rather short fragments, the longest being about 22 mm., with an impression showing that it once reached a length of fully 36 mm. The diameter is about 2·5 mm. Over the whole specimen there is no evidence whatever that any of the tubes branched, although an artist would not need much imagination to represent them as having done so. Saporta both describes and figures his species as "pourvus çà et là d'une ramification solitaire", and this, if well founded, constitutes a clear difference.

The tubes are made up of convexly rounded pellets, brownish in colour, and apparently composed of the minute brownish sand-grains that may be seen with a lens scattered throughout the fine bluish-grey clay of the matrix. The pellets are usually elliptical, with their long axis more or less transverse to the tube.

I do not hesitate to regard these tubes as having been made by such a Tubicolous Annelid as *Terebella figulus* or a *Sabella*; but the question of a name gives rise to much hesitation.

Phymatoderma cælatum, which they so markedly resemble, "s'écarte très-sensiblement, selon nous [Saporta], de toutes les Algues fossiles signalées jusqu'à présent [1873]." This one can understand if it is not an alga but an annelid. But then it would not be a *Phymatoderma*, which appears to have been based by Brongniart on the Liassic *Algacites granulatus* Schlotheim. *P. cælatum* was founded on a specimen from the Oxfordian of Bouches-du-Rhône.

The genus *Granularia* was established by Pomel (1847) with *G. repanda* of Corallian age as genotype. References and details will be found in Saporta (1873, op. cit., p. 108), whose figure of the genotype (pl. xii, fig. 1*a*) shows an obviously branching form. There seems no reason why we should not speak of *Granularia cælata* (Sap.); but our Albian form, though closely resembling that Oxfordian species, is not likely to have been identical. Therefore we may speak of it for the present as *Granularia* cf. *cælata* (Sap.).

To avoid any confusion of the nomenclature, I wish to say quite definitely that I use the names *Keckia*, *Granularia*, etc., only on the supposition that their genotypes, and consequently the genera themselves, are of animal origin. Should those species, with their genera, ultimately be retained among plants, and should the British Cretaceous species here discussed be accepted as Annelida, then no use by me of the names *Keckia*, *Granularia*, etc., is to be regarded as establishing them as new genera of animals.

Summary.

The tubes formed of fish-debris, found throughout the Chalk of England, described by Mantell (1822) as *Muræna* (?) *lewesiensis*, referred by L. Agassiz (1844) to *Dercetis elongatus*, and placed among Annelida Tubicola as *Terebella lewesiensis* by William Davies (1879), are here described with more precise detail and retained in the position assigned to them by Davies. A diagnosis is provided and a holotype selected.

A specimen from the Gault, of similar nature but larger, is made the type of a new species, '*Terebella*' *lutensis* (Fig. 6).

Similar tubes from the Cenomanian, built of Conifer debris and Echinoderm debris, are described, and the question whether these differences of composition indicate a difference of species is discussed, but left open for the evidence of further material. Such tubes may for the present be known as '*Terebella*' cf. *lewesiensis* (Figs. 7, 8).

Tubes without extraneous building material and with a cancellar ornament are also found in the Cretaceous rocks of England, and some were referred to *Terebella lewesiensis* by Davies. All those from the Chalk are here separated as '*Terebella*' *cancellata*, n.sp. (Figs. 3–5).

Two tubes made of mud bricks are discussed. One, apparently of Lower Cenomanian age, is referred to the rather doubtful genus *Keckia* (Fig. 1). The other, from the Gault, is referred to *Granularia* (Fig. 2). Both these genera are held to be of Annelid origin.

IV.—Note on the 'Lower Tremadoc' Rocks of St. David's, Pembrokeshire.[1]

By John Pringle.

In the year 1866 Hicks and Salter recorded[2] the occurrence of certain rocks in the neighbourhood of St. David's which they regarded as Tremadoc deposits. The beds appeared to them to rest conformably on the Lingula Flags, but when the rocks were compared with those of the Tremadoc area striking lithological differences were noticed. Accompanying the report was a list of fossils collected from the beds, and the fauna was so wholly unlike that of the North Wales deposits that the authors were led to conclude that the dissimilarity was due to the conditions under which the strata were deposited.

In 1873 the group was again described by Hicks.[3] In this paper and in a later one[4] the author gave an account of the lithological characters of the rocks, their relation to other formations, and their distribution in the area, describing in his earlier contribution[3] many fossil forms which he regarded as new. Despite the somewhat unsatisfactory conclusions recorded in his joint paper with Salter, Hicks expressed his conviction in the two papers that the strata were Lower Tremadoc.

Since the publication of the last-mentioned memoir, and especially in the light of evidence collected elsewhere, doubts have arisen as to the correctness of Hicks' views. With a hope of clearing up the question of age, the writer was instructed to collect from the group where it is best exposed in the St. David's district, namely, on Ramsey Island and on the mainland at the north end of Whitesand Bay.

Ramsey Island.

The 'Lower Tremadoc' rocks occupy a small area in the north-east corner of Ramsey Island. They form a narrow strip between Ogof Velvet and Bay Ogof Hên (see Sketch-map). They extend for a short distance southwards, but are cut out by a fault

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

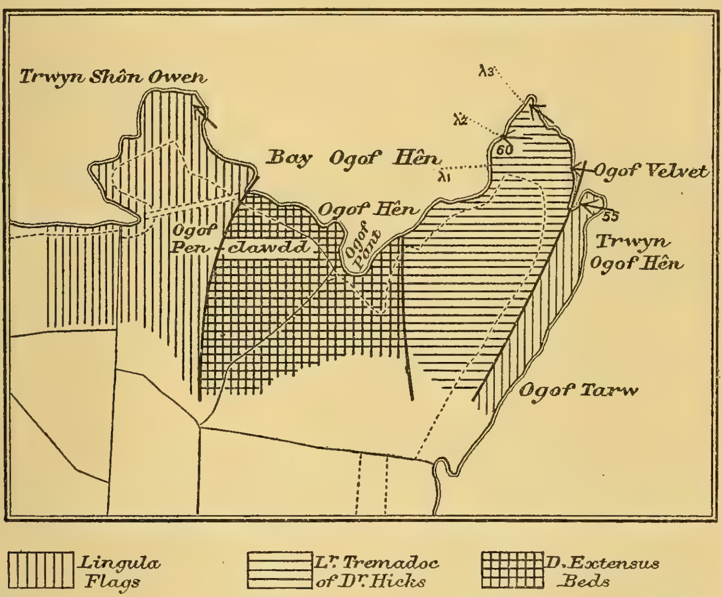
[2] Hicks & Salter, Second Report on the Menevian Group and other formations at St. David's, Pembrokeshire: Rep. Brit. Assoc., Nottingham, 1866, p. 184.

[3] H. Hicks, "On the Tremadoc Rocks in the neighbourhood of St. David's, South Wales, and their fossil contents": Q.J.G.S., vol. xxix, p. 39, 1873.

[4] H. Hicks, "On the Succession of the Ancient Rocks of St. David's": Q.J.G.S., vol. xxxi, p. 167, 1875.

and are brought against shales belonging to the zone of *Didymograptus extensus.* The series is not well exposed inland, but is seen to advantage in the cliff at the north end of the island.

The lowest beds of the group are thin grey sandstones with some shales. Hicks regarded them as forming the base of the 'Tremadoc', and they extend along the foot of the cliff on the west side of Ogof Velvet. They are succeeded by grey sandy shales with thin lenticles of sandstone, and these in turn are overlain by bluish-grey iron-stained mudstones, which are highly fossiliferous. It was from the latter that Hicks obtained his fossils. The strata, which are about 1,000 feet thick, have an average dip of about 60°, and they strike from N.E. to S.W.



Sketch-map[1] of the north-eastern portion of Ramsey Island. Scale, 6 inches to 1 mile. Vertical shading indicates Lingula Flags; horizontal shading indicates Lower Tremadoc of Dr. Hicks; cross-hatching indicates *Didymograptus extensus* beds. Fossil localities shown thus: λ 1, λ 2, etc. Thick lines represent faults.

Hicks and Salter[2] believed that the 'Tremadoc' rested conformably on the Lingula Flags, and that the latter gradually passed upwards into the former group. They were clearly in error, however, as the junction proves to be faulted. The line of dislocation, which runs nearly parallel with the strike, can be seen descending the cliff above Ogof Velvet. The detection of this fault greatly simplified

[1] The line-drawing from which this illustration was prepared was kindly made by Mr. R. Ashborn.

[2] Hicks & Salter, Second Report on the Menevian Group and other formations at St. David's, Pembrokeshire: Rep. Brit. Assoc., Nottingham, 1866, p. 184.

the question of the horizon of the group, and considered with the evidence yielded by the fossils collected at localities λ 1, 2, and 3 (see Sketch-map), it became certain that the beds are of Lower Arenig age. Of the fossils collected the following forms have been identified:—[1]

Orthis calligramma, Dalm., var. *carausi*, Salter.
O. menapiæ, Hicks.
Calymene tristani, Brongn. [*Neseuretus ramseyensis*, Hicks].
Ogygia selwyni (Salter).

The succession of the Arenig rocks at the north end of Ramsey Island is briefly as follows. The lowest beds of the group are a series of thin grey sandstones and sandy shales, which pass upwards into dark-grey iron-stained mudstones which are abundantly fossiliferous. They are faulted against the Lingula Flags at Ogof Velvet, and are not conformable as has been supposed hitherto. A fault on the west side of the fossiliferous mudstones brings the latter against the thin-bedded chocolate-stained shales of the *D. extensus* zone, so that a considerable thickness of shales belonging to the lower part of the zone seen on the mainland at Porth Lleuog, Whitesand Bay, is cut out. The non-occurrence of these shales on Ramsey Island has been previously noted.[2] On the west side of the island the *D. extensus* shales are brought by another dislocation against the Lingula Flags, which form the headland of Trwyn Shôn Owen.

The above succession is similar to that observed in the Arenig rocks in the Carmarthen district,[3] where grits, gritty shales, and conglomerates, associated with a similar fauna, are strongly developed at the base of the shales belonging to the *D. extensus* zone.

Whitesand Bay.

Hicks thought that the lower part of the 'Tremadoc' group was to be seen resting conformably on the Lingula Flags at the north end of Whitesand Bay. He believed the upper members to be cut out by a fault which runs in a north-easterly direction, and brings down Arenig shales on the north side of Trwyn Hwrddyn.

An examination of the section in the light of the results obtained on Ramsey Island convinces me that these rocks do not belong to the group to which they have been assigned. Lithologically, they are inseparable from the Lingula Flags, and the beds which form the promontory of Trwyn Hwrddyn are similar to the flags on the east side of Ogof Velvet. No fossils were obtained except *Lingulella davisi*, which occurs in great abundance.

Further north, at Llanveran, the group is to be seen in its entire thickness, but time did not permit me to visit the localities. Hicks, however, records from the beds the same fauna as he obtained from the 'Tremadoc' of Ramsey Island, so that their Arenig age may be safely assumed.

[1] The Trilobites were kindly identified by Mr. Philip Lake.
[2] Gertrude L. Elles, "Some Graptolite Zones in Arenig Rocks": Geol. Mag., 1904, p. 209.
[3] H. H. Thomas, in the *Geology of the South Wales Coal-field*, pt. x (Mem. Geol. Surv.), 1909, p. 10.

The only other area where 'Tremadoc' rocks occur in the St. David's district is at Tremanhire, north-east of Solva. They have been examined recently by Mr. H. H. Thomas and Professor O. T. Jones, who kindly inform me that they consider the rocks to be undoubtedly of Arenig age. They yield an *Ogygia*, probably *O. selwyni*.

V.—What is Laterite?

By L. Leigh Fermor, A.R.S.M., D.Sc., F.G.S., Geological Survey of India.

(*Concluded from the November Number, p. 516.*)

Laterite a stratigraphical as well as a petrographical term.—In this paper I have urged the advisability of applying the terms *laterite*, *lithomargic* and *quartzose laterite*, *lateritic lithomarge*, etc., to certain rocks, all of which some geologists would include under the term *laterite*. This restriction of the use of the word *laterite* is advocated in the petrographical sense. Besides being used as a rock name, this word is also applied as the name of a geological formation in India, ranging from Tertiary, through Pleistocene, into recent times,[1] for probably in some parts of India, as in other parts of the tropics, laterite is still in process of formation. As the name of a formation, the term *laterite* comprises, not only substances that petrographically are true laterite, but also lithomargic and quartzose laterites, lateritic lithomarges, and lithomarges that are practically free from lateritic constituents, not to mention various laterite-cemented detrital rocks. Consequently, in mapping geologically in India it is necessary to include as laterite many rocks that petrographically are not laterite.

The parallel to such a twofold use of the word is easy to find. The Charnockite Series includes members that are not charnockite. The Bengal Gneiss is the name of a geological formation containing not only gneisses, but also limestones, dolomites, and mica-schists. No one wishes to call a piece of limestone from this formation "a piece of Bengal gneiss". Similar examples occur in the stratigraphical nomenclature of most countries.

It is probably failure to notice this twofold application of Buchanan's original term in Indian geology that has led geologists in other parts of the world to a comprehensive use of the term petrographically, as well as stratigraphically. There can be no objection to engineers using the term in a wide sense, for although some of the substances designated *laterite* by them will not be laterites in the petrographic sense, yet they will in most cases belong to lateritic formations.

IV. The Application of the term Bauxite.

The question whether the word *bauxite* should be retained as the name of a definite mineral or not is not difficult to answer if one appeals to the historical side of the subject. P. Berthier,[2] in 1821, described a supposed iron-ore (*minerai de fer*) from Beaux near Arles in Provence, which he had analysed and found to be "composé

[1] *Manual of the Geology of India*, 1893, p. 369. On p. 385 the use of this word as a lithological and a chronological term is discussed, and the former use preferred.

[2] Ann. des Mines, vi, pp. 531–4.

d'hydrate d'alumine, mélangé d'oxide rouge de fer", containing 52·0 per cent of Al_2O_3, 20·4 per cent of H_2O, and 27·6 per cent of Fe_2O_3, with a trace of Cr_2O_3. Berthier says that the iron is evidently present in the mineral in the anhydrous condition and in "l'état de mélange", and that "le minéral pur" would be composed of 72 per cent of Al_2O_3 and 28 per cent of H_2O, corresponding nearly to $Al_2O_3 . 2H_2O$. He applies the terms *minerai*, 'ore,' and *minéral*, 'mineral,' indiscriminately to his specimen, and as he proposes no name for the substance it is difficult to say whether he regarded it as a definite mineral, as the construction of a definite formula would seem to indicate.

A. Dufrénoy, on p. 347 of vol. ii of his *Traité de Minéralogie* (1845), refers to the substance analysed by Berthier, and says "Elle ne peut être regardée comme une espèce minérale". But in the index to vol. iii of this work, published in 1847, the following entry occurs (p. 799): "Beauxite, *nom donné* à l'alumine hydratée de Beaux," the reference being to vol. ii.

St. Claire Deville[1] in 1861 contributes a paper entitled "De la Présence du Vanadium dans un Minerai Alumineux du Midi de la France". He heads his first chapter thus: "Minerais Alumineux ou Bauxite," showing that he regarded *bauxite* (the correct spelling) as an *aluminous ore*; further, he mentions Berthier as the originator of the name, as follows: "ce minerai particulier que M. Berthier a appelé la *bauxite*." On p. 321 Deville gives a number of analyses, one of which shows 48·8 per cent of Fe_2O_3 and only 33·2 per cent of Al_2O_3, indicating an extension of the term *bauxite* to include very ferruginous varieties. The amount of water present in these analyses is generally insufficient for the formation of $Al_2O_3 . 2H_2O$. The presence of TiO_2 is shown. On p. 324 the term *bauxite* is applied to an iron-ore from Paradou in Provence containing 60 per cent of Fe_2O_3 and 18 per cent of Al_2O_3 and TiO_2.

Sufficient is quoted above to show that the name *bauxite* was not given to a definite mineral, but to an impure aluminium-ore of very variable composition, and that consequently its application has, really, always been to a rock and not to a mineral. The assumption, perhaps only intended as a suggestion, of the existence of the definite compound $Al_2O_3 . 2H_2O$, first made by Berthier, and adopted by Dana, is not apparently justifiable, and it seems that bauxite must be regarded as a true rock, and the term *bauxite* must consequently be available to petrographers for use in this sense. The matter is summed up admirably by Professor Lacroix on p. 342 of vol. iii of his *Minéralogie de la France et de ses Colonies* (1901). Lacroix says that the examination of a large number of analyses shows that bauxite, where it contains the minimum of impurities, approaches nearer to the composition of diaspore than of any other mineral, and that bauxite is to be regarded as constituted of various colloid hydroxides of aluminium, mixed with the corresponding hydroxides of iron, and with various impurities, clay, quartz, sand, etc. "C'est en réalité une véritable roche."[2]

[1] Ann. Chim. Phy., ser. III, lxi, pp. 309–42.

[2] Since the above was written we have received in the library of the Geological Survey of India, vol. cxlviii of the *Comptes Rendus* (1909), in which there are

The term *bauxite* was, as is seen above, extended by Deville to rocks very high in Fe_2O_3, and it has often been used in France to correspond with rocks ranging from the most aluminous to the most ferruginous laterites of India. Mr. Scrivenor's contention, then, would seem to be upheld, namely, that we can replace the term *laterite* by the word *bauxite*. But it should be remembered that the term *laterite* dates from 1807, and the term *bauxite* only from 1847. The French mineralogists have, therefore, used the word *bauxite* for a substance for which a name already existed, and therefore if any change were necessary we should call upon our French colleagues to drop the term *bauxite* and to substitute for it the term *laterite*. Such a course would be absurd, and I think the most desirable procedure is to restrict the term *bauxite* to those varieties of *laterite* sufficiently rich in alumina to be used as aluminium-ores. If the rock contains more Fe_2O_3 than Al_2O_3, it is not likely to be used as an aluminium-ore, and therefore I think the term *bauxite* might be restricted to those *laterites* that contain at least as much Al_2O_3 as Fe_2O_3.

Lacroix follows a somewhat similar course. He says (p. 346) that he reserves the name *bauxite* (*sensu stricto*) for rocks of the type of those of Provence, and to the very aluminous and often pisolitic patches (*accidents*) in *laterite*, whilst he uses the word *laterite* in its customary sense—defined earlier (p. 345) as the red rock that is formed in tropical climes by the decomposition in situ of the most diverse rocks, e.g. granites, diorites, basalts, gneiss, etc.—and applied it in addition to rocks of the same composition, such as the bauxites of the Puy-de-Dôme (alteration of gneiss) and of Hesse (alteration of basalts), of which one can prove the formation in situ at the expense of silicate rocks (*roches silicatées*).

In closing this section it is interesting to notice that Mr. Scrivenor, whilst quoting Professor Lacroix to the effect that *bauxite* is a rock and not a mineral, has apparently overlooked the same author's distinction between the terms *bauxite* and *laterite*, which conflicts with his (Scrivenor's) suggestion that the term *laterite* should be replaced by the term *bauxite*.

V. The Lateritic Earths of British Guiana.

I will conclude this paper with a brief consideration of the surface decomposition rocks of British Guiana, as discussed in this Magazine (already summarized), and which have given rise to this communication. I will take Professor Harrison's paper entitled "The Residual Earths

two notes, on pp. 936–8 and 1115–18 respectively, by M. H. Arsandaux, "Sur la composition de la bauxite." In the earlier note it is shown by treating certain French bauxites with concentrated HCl, and then attacking the insoluble residue with concentrated H_2SO_4, that nearly all the alumina is present as $Al_2O_3 . H_2O$, thus corresponding, although the rocks were found in thin sections to be completely isotropic, to the composition of diaspore. The iron is shown to be present as anhydrous Fe_2O_3. The titania is believed to be present as meta-titanic acid, $TiO_2 . H_2O$, and the small quantities of silica as $2H_2O . Al_2O_3 . 2SiO_2$ (the kaolin or lithomarge formula). The second note deals with the more siliceous bauxites (also completely isotropic), and indicates the existence of every gradation between clay and $Al_2O_3 . H_2O$.

of British Guiana commonly termed 'Laterite'", in the GEOLOGICAL MAGAZINE, 1910, pp. 439, 488, and 553.

On p. 441 is given a table of analyses of "laterite soils". Only one of those soils contains less than 50 per cent of "gravel + quartz sand + clay, silica, and insoluble silicates", namely, the soil derived from hornblende-schist at Maburima. This might be termed *argillaceous laterite*, the adjective applicable depending on the exact nature of the 29·16 per cent representing the third item above. Some of the other soils, namely, those containing considerable amounts of oxides of iron and aluminium, such as Nos. 1, 4, 9, 12, and 13, might be termed *lateritic clay*, *soil*, or *sand*, whilst the majority of the others would be best designated clay, gravel, sand, or soil, without the dignity of the adjective 'lateritic'.

In Table II, on p. 444, showing decomposition products from Issorora Hill, the *red lateritic earth* is correctly named. The *concretionary ironstones* and *ironstone pisolites* are also correctly named, but might be regarded as varieties of laterite, being the results, in fact, of the segregation of the lateritic constituents of the *lateritic earth*.

In Table V, on p. 447, three rocks are boldly classed as laterites. To none of them is the name, in my opinion, applicable. The earths from Tumatumari, Omai Falls, and Mazaruni contain 47·3, 45·8, and 39 9 per cent of lateritic constituents respectively, and should, by preference, be termed *lateritic earths*.

The sericitic earth represented by Table VII on p. 449 contains 37·6 per cent of lateritic constituents and might also be termed *lateritic*. The three samples of *bauxite* or *laterite* shown in Table IX on p. 451 are correctly so named, and are in fact the only "residual earths" noticed in Harrison's paper to which the term can be correctly applied, with the exception, perhaps, of the segregations of concretionary ironstone or lateritic iron-ore in the red lateritic earth of Issorora Hill.

But these three samples which I regard as the only true laterites described by Harrison, represent, according to this author (p. 488),

"the extreme of the formation of laterite, where the igneous rock, in place of weathering to a mixture of quartz, of kaolinite, of bauxite, and of the oxides and hydrates of iron, changes almost completely to quartz and to hydrates of alumina and the oxides and hydrates of iron."

Further, he says (p. 489) that the foregoing examples, that is to say, all the various soils, earths, and laterites noticed above,

"represent the types of the residual deposits in situ in British Guiana, which I have regarded as and termed laterite."

And in Table X he gives the mean proximate composition of the British Guiana lateritic earths examined by him as follows:—

Quartz	24
Iron-ores (including pisolites)	32
Kaolin, Sericite, and other felspathic debris, etc.	24
Bauxite	20
	100

This corresponds to 52 per cent of lateritic material and 48 per cent of non-lateritic material, and, although just within the limits for laterite, yet judging from Professor Harrison's descriptions and the composition of the earths taken individually, I think he would be more in conformity with usage were he to use the term *lateritic earths* when speaking of these substances as a whole, and not to use the terms 'laterite' and 'lateritic earth' as equivalent and interchangeable.

On p. 494 analyses are given of two pisolitic 'laterites' which evidently deceived Professor Harrison as much as the similar Indian pisolitic lithomarge of which the analysis is given on p. 510 deceived Maclaren and me; for the analyses quoted show that instead of obtaining rocks to correspond to Du Bois' pisolitic iron-ore and oolitic bauxite as he intended, Harrison has collected merely a ferruginous kaolin in one case, and a less impure kaolin or lithomarge in the other.

The Laterite of Surinam.—On p. 558, Table XXIV, three technical analyses of laterites from Surinam are quoted from Du Bois' monograph. These show respectively 91·4, 84·1, and 94·5 per cent of hydrated oxides of alumina and iron, and two of them are nearly as pure as some of the best Indian laterites.

On the bottom of p. 558 Harrison refers, in the following words, to the only laterite he has seen in Surinam :—

"Here there is a gradual change of the decomposing schist into its laterite, the change extending to considerable depths in the schist. The lateritic earth, covered in places by concretionary masses of ironstone, reminded me of Logan's account of the ferruginous and silico-ferruginous rocks and laterite of Singapore . . . and of Mr. Scrivenor's description of the laterite of the Malay Peninsula . . ."

Judging from the description this Surinam rock is not a residual deposit, but a metasomatic replacement deposit, for which I have offered the term *lateritoid*, which I have already remarked seems applicable to Mr. Scrivenor's laterite.

Professor Harrison is, however, only following Du Bois[1] in his wide extension of the term *laterite*, for the latter in his paper on the laterite of Surinam divides his laterites into—

(1) Primary (Eluviale) laterite, or laterite rich in silica, and

(2) Secondary (Alluviale) laterite from laterite detritus, or laterite rich in aluminium hydroxide.

But Du Bois has also, I think, extended the term too widely, and although some of the analyses given in his paper represent rocks that can fairly be designated laterite, the remainder cannot, in my opinion, be so classed; for example, the decomposition products of diabase given on p. 24 of Du Bois' paper, which are merely *partially altered diabase*. The analyses on p. 28 represent substances that contain some 65 per cent of quartz and clay, and might be called *lateritic sand* or *earth*, but might also be allowed the names *alluvial* or *secondary laterite*, given to them by Du Bois. The analyses given on p. 37, however, represent *true laterites*. These are the ones quoted by Harrison.

From the foregoing it will be seen that if one accepts the ideas as to what is a true laterite put forward in this paper, it becomes

[1] Tschermak's *Mittheilungen*, 1903, p. 18.

apparent, judging from the work of Harrison and Du Bois, that the term has been too widely used in the Guianas.[1]

Hardening properties of laterite.—Professor Harrison's paper bristles with other controversial points, but this communication has already grown to an inordinate length, and consequently I will refer to one other point only. It is a mistake to think that all laterites will behave in the way that the laterite first described by Buchanan behaved, namely, that they will be found to be soft when first quarried and will harden on exposure to the air, except to the small extent that most rocks harden owing to evaporation of contained moisture. In my experience certain varieties of laterite (e.g. high-level laterites of Balaghat) that both in chemical composition and in physical appearance are true laterites, and to which Buchanan would undoubtedly have applied the term, are not found to be markedly softer when quarried than after exposure to the air. Further, Harrison on p. 493 of his paper describes a clay-like mass that hardens on exposure, and which analysis shows to contain 50·3 per cent of felspar and 22·1 per cent of kaolinite, with only 24·5 per cent of lateritic constituents.[2]

Consequently, to appeal to this setting property of a rock, in

[1] The same remark probably applies to many another tropical area in which *lateritic rocks* occur. Thus, I have quoted with approval the work of M. Arsandaux on the French bauxites (see note, p. 561). But I do not agree with his two later notes (pp. 682–5 and 1082–4 respectively, of C.R., vol. cxlix, 1909), in which he gives and discusses analyses of 'laterites' from the *French Congo* and the *Soudan*. As before, he extracts the Fe_2O_3, and in this case the free Al_2O_3 as well, with concentrated HCl, and decomposes the insoluble residue by means of concentrated H_2SO_4. To the former fraction (my *lateritic constituents*) he pays no attention, but shows that the portion insoluble in HCl, which amounts to 68–99 per cent of the whole rock, varies in composition *from* micaceous alumino-potassic silicates allied to muscovite *to* kaolin practically free from alkalies. Most of these rocks have been formed in situ by the weathering of crystalline rocks (granites, schists, etc.), and it is evident from the author's analyses and descriptions that his so-called laterites are really *clays* containing a certain, usually small, proportion of lateritic material. The very uppermost crust may be laterite, properly so called, but no analyses of this are given.

Reference may also be made to the analyses of 'laterites' (derived from basic rocks—diabase and ophite), from *French Guinea*, by J. Chateaud and P. Lemoine (C.R., vol. cxlvi, pp. 239–42, 1908). The analyses show, in most cases, a considerable amount of silica, but it is apparently (p. 241) almost entirely in the free condition. On this assumption, No. 11, with only 5·52 per cent of SiO_2, is a *true laterite*; Nos. 136, 179, 180, 181, and 185, containing 12 to 28 per cent of SiO_2, are *quartzose laterites*, whilst No. 195 (derived from phyllite) with 62·30 per cent of SiO_2 cannot be regarded as a laterite at all. That the authors do not regard these rocks as completely formed laterites (my true laterites) is indicated by the following passage: "La *silice* est presque complètement rendue libre; les $\frac{4}{5}$ environ ont été entraînés; le reste, qui aurait probablement disparu si la latéritisation avait été complète, ne joue qu'un rôle insignificant et est, en majeure partie, à l'état de silice libre." A diagram illustrates the chemical losses involved in the formation of laterite No. 11 from diabase No. 2, on the assumption of constant TiO_2.

[2] W. T. Blanford, in his account of the Laterite of Orissa (Mem. Geol. Surv. India, i, p. 283, 1859), referring to the lithomarge underlying the laterite, says that on exposure it becomes hard like laterite.

deciding whether or not it is a laterite, is unsatisfactory, unless considered in conjunction with the chemical composition.

VI. Summary.

1. The term *laterite* is used in two ways, namely, *stratigraphically* as the name of a geological formation, and *petrographically* as the name of a tropical superficial rock. This discussion relates only to the use of the term as a rock name.

2. *Laterite* (or rather some varieties of it) is formed by a process, the *modus operandi* of which is not discussed here, by which certain rocks undergo superficial decomposition, with the removal in solution of combined silica, lime, magnesia, soda, and potash, and with the residual accumulation, assisted, no doubt, by capillary action, metasomatic replacement, and segregative changes of a hydrated mixture of oxides of iron, aluminium, and titanium, with, more rarely, manganese. These oxides and hydroxides of iron, aluminium, titanium, and manganese are designated the *lateritic constituents*.

3. This residual rock is *true laterite*, and the presence of any considerable proportion (>10 per cent) of non-lateritic constituents requires expression in the name, as it always indicates want of completion in the process of lateritization. True laterite contains, then, 90 to 100 per cent of lateritic constituents.

4. There is often a gradation in composition between true laterite as defined above and lithomarge, which is taken as the amorphous compound of composition, $2\,H_2O \,.\, Al_2O_3 \,.\, 2\,SiO_2$ corresponding to the crystalline mineral kaolinite of the same composition. For the rocks intermediate between laterite and lithomarge the terms *lithomargic laterite* and *lateritic lithomarge* are available, the former being applied to forms containing 50 to 90 per cent of lateritic constituents, and the latter to forms containing only 25 to 50 per cent of lateritic constituents.

5. The presence of any considerable amount of quartz, either residual or secondary (this form has not, so far as I am aware, yet been noticed in Indian laterites), should be indicated by terming the rock a *quartzose laterite*, unless the amount of quartz and other non-lateritic constituents exceed 50 per cent, when the word *laterite* should appear only in the adjectival form, as in paragraph 4.

6. Many rocks to which the term *laterite* has been applied would be more aptly termed *soils*, *earths*, *clays*, and *sands*, with (>25 per cent) or without (<25 per cent of lateritic constituents) the attributive *lateritic*.

7. *Varieties* of the rock defined as true laterite are those in which one of the constituents is present in relatively large amounts, namely, the highly aluminous variety, *bauxite*, the highly ferruginous variety, *lateritic iron-ore*, and the highly manganiferous variety, *lateritic manganese-ore*. From this it follows that alumina cannot be regarded as an essential constituent of laterite, although it is usually present in smaller or larger quantity.

8. The property of *hardening on exposure* to the air is characteristic of many varieties of laterite, but it is not an essential property; for some laterites do not exhibit it, whilst cases have been recorded of

rocks that show this property and yet cannot possibly be termed laterite, although they probably contain a certain quantity of hydroxides of iron and aluminium, to the dehydration of which the setting of laterite is usually ascribed.

9. For any rocks (such as some of the *pisolitic limonites*), associated with the laterite formation, that have probably been formed by chemical deposition in lakes or bogs the name *lake laterite* is suggested. This is regarded as an unimportant variety of laterite.

10. Certain lateritic rocks that have been formed by the metasomatic replacement at the outcrops of a variety of rocks, and which cannot be regarded as residual products of the decomposition of the underlying rocks, have been designated *lateritoid.* Such rocks can usually be recognized by their preserving unaltered or but partly altered fragments of the underlying rocks, and of retaining signs of the original bedding-planes of the rocks they have replaced. They have hitherto always been found on the upturned outcrops of the quartzites and argillaceous schists and phyllites of the Dharwar formation, and usually take the form of iron-ore or manganese-ore, alumina not being an abundant constituent of the lateritoids.

11. Rocks formed by the accumulation of detritus from masses of chemically-formed laterite (or of lateritoid) either alone, or mixed with extraneous materials, such as fragments of quartz or gneiss, may be termed *detrital laterites*, as an alternative to which the term *lateritite* is suggested.

12. Most of the so-called laterites of the Guianas as described by Harrison and Du Bois are not true laterites unqualified, but are either *quartzose* or *lithomargic laterites*, or *lateritic earths.* Many of them are detrital rocks, sometimes rich enough in lateritic material to be called *detrital laterite* or *lateritite.* True laterites do, however, also occur.

13. The classification of laterites and associated rocks put forward in this paper is, of course, of a more or less tentative nature, and although it is believed to be a workable system of nomenclature, yet future work will doubtless show the desirability of various modifications and amplifications.

REVIEWS.

I.—The Ice Age in North America and its Bearings upon the Antiquity of Man. By G. Frederick Wright, D.D., LL.D. Fifth Edition. 8vo; pp. xxi, 763, with 10 plates, 3 maps, and 196 text-illustrations. Oberlin (Ohio), Bibliotheca Sacra Company; London, Charles Higham and Son; 1911. Price 20*s.* net.

A NEW edition of Dr. Wright's great work will be widely appreciated by students and teachers, giving as it does such a clear and comprehensive view of the grander features in Glacial geology that are so well exhibited in North America. Although, as the author remarks, later investigations have not seriously affected the main theories adopted in 1889, when the first edition of his work was published, yet there have been further destructive criticisms of

Croll's views on the cause of the Glacial Period and of astronomical calculations respecting Glacial chronology. On the other hand, the views on the former extent and action of land-ice, enunciated by Agassiz in 1840, have gained almost universal adherence, and there remain very few geologists whose opinions can be said to be seventy years or more behind the times.

In the preliminary account of existing glaciers and ice-sheets a good deal of new material has naturally been gathered from researches in Greenland, Central Asia, and the Antarctic regions. In Alaska, again, interesting instances have been recorded of the advance and retreat of the glaciers bordering Yakutat and Glacier Bays. In the former bay a remarkable advance in the ice has been attributed by Professor Tarr to the effect of an earthquake in 1899. By that disturbance a portion of the coast was elevated 47 feet, and thereby large quantities of snow were probably shaken from the more elevated peaks upon the head of the glaciers. Interesting, too, are the accounts of the Muir Glacier, the ice from which nearly filled Glacier Bay a century ago. Owing to the present recession a buried forest with many upright stumps of trees has been partially exposed beneath sand and gravel, and the author remarks, "There can be no doubt that, after the accumulation of sand burying the forest, the glacier advanced for a great distance over it, attaining a thickness at that point of two or three thousand feet." This leads to some remarks on the capacity of ice to move over such deposits without disturbing them. No doubt a great deal depends on the form and composition of the land-surface over which the ice passed, whether smooth or irregular, evidences of drag and disturbance being more often seen where the surface was uneven or where boulder-clay rests on mixed strata of clay and gravel.

Greenland, regarded as an island of continental proportions and the most important accessible field for glacial observations, is almost wholly covered by an ice-sheet, having an area of about 575,000 square miles, a length of 1,500 miles, and a width of 700 miles. The author, however, remarks that "The absence of glacial phenomena north of the range of mountains which forms the southern boundary of Alaska, and over the adjacent plains of Northern Siberia, completely disproves the once current theory that the glacial period was characterized by a vast ice-cap extending in all directions from the pole".

The Ice Age in North America, as in Europe, "began and ended in a great number of local glaciers which became confluent and continuous only during the middle of the period." The area covered by the ice at its maximum extension is shown in fig. 62, and other maps indicate in more detail the southern limit of the ice-sheet and drift.

On the coast of Maine the ice is reckoned to have been more than 1,500 feet thick, while over the central portions of the glaciated area in North America it may have been as much as three miles. This latter calculation is based on the evidence of movement of ice from Labrador to the southern part of Illinois, a distance of about 1,600 miles. It is estimated that there must have been an average slope of 10 feet to the mile, and that the movement must have been produced mainly by the simple accumulation of ice.

The extreme glacial margin is often, but not always, marked by a distinct terminal moraine, with a certain amount of intra-morainic and extra-morainic drifts. The last-named drifts include what is termed the "fringe" or "attenuated border" of sporadic or modified glacial deposits, which may extend about 20 or 30 miles south of the glacial margin; and they comprise coarse 'over-wash' gravel and boulders formed by marginal drainage. As the author remarks, "it has been questioned by some whether the larger part of the grist of the glacier has not been thus transported far beyond the extreme limits reached by the ice itself," and by subglacial streams "surcharged and milky-white with sediment". The terminal moraines form marked features, rising in places from 150 to 300 feet above the general level of the country, accompanied by huge boulders and by kettle-holes and the small lakelets enclosed by them. Other moraines have been attributed by some geologists to a "second Glacial epoch", but they are more appropriately termed "moraines of retrocession"; and there are also minor local moraines.

It is estimated that not less than one million square miles of territory in North America "is covered with an average depth of fifty feet of glacial débris, forming the most permanently productive part of the continent".

Various stages in the Glacial Period, indicating advance and retreat of the ice, have been described more or less locally under the names Sub-Aftonian, Aftonian, Kansan, Iowan, Illinoisan, and Wisconsin (the latest). In the earlier three stages, the deposits are more oxidized—a feature attributed to their antiquity; the materials having been the first taken up by the advancing ice from the already decomposed and oxidized soils and subsoils.

Certain 'forest-beds' and peaty deposits have been taken to mark a second Glacial epoch or one or more Interglacial periods. The author, however, remarks that while in places these accumulations have glacial drift both under and over them, they may belong to various times of recession and advance of the ice, and may in fact have originated "in front of the margin of the slowly retreating ice if only there were comparatively brief periods of readvance". Moreover, the buried vegetable deposits "do not mark a warm climate, but a climate much colder than the present", and "it may well be questioned whether an interval of two or three centuries would not suffice for the accumulation of the peat described". Most of the facts relating to the Ice Age support "the theory of but one epoch with the natural oscillations accompanying the retreat of so vast an ice-front".

The influence on drainage systems is not the least fascinating of subjects connected with the Glacial Period. The infilling of pre-Glacial valleys so diverted the lines of superficial drainage that many streams took courses over rocky beds at levels higher than they formerly occupied, and the glaciated region became one of waterfalls. The falls of Niagara are an example. Before the Ice Age nearly all the streams in the eastern United States occupied deeper channels than they do now. "There were then probably no Great Lakes, and few, if any, waterfalls, as there are now no lakes and waterfalls south of the glaciated region. All the rivers had cut their channels down so low that they drained to the bottom any lakes that may have once existed." The effect of the icy barrier in damming up streams and rivers and forming huge temporary lakes and smaller lakelets is well told in these pages from the observations of numerous geologists, including the author; while in other instances the torrents of glacial water that were poured into the Mississippi and Ohio were of great magnitude, and there are indications that glacial floods rose in the Lower Missouri to a height of 200 feet or more.

Dr. Warren Upham contributes an account of "The Glacial Lake Agassiz", and particulars of Lake Allegheny are printed from an unpublished report of Professor E. H. Williams.

Of the erosive and transporting power of moving ice much information is given; and the view advocated by Newberry that glacial ice "was a prominent agent in the formation of the Great Lakes" is sympathetically treated by the author.

We have given, mostly in his own words, some account of the principal subjects dealt with in this volume: with these we should also mention the influence of the Glacial Period on the distribution of plants and animals. To the two chapters on "The Cause of the Glacial Period" some "Supplemental Notes" are contributed by Dr. Upham, who deals with the effects of great epeirogenic elevations, and with the views of Messrs. Chamberlin and Salisbury on the meteorological effects of the depletion of atmospheric carbon dioxide by reason of the increased area of land and the increased carbonation and oxidation of rocks. Winds and ocean currents are naturally regarded as important factors in the Glacial Period, and reference might have been made to Mr. F. W. Harmer's paper on "The Influence of the Winds upon Climate during the Pleistocene Epoch" (Q.J.G.S., lvii, p. 405, 1901). With regard to the date of the Glacial Period, the author is disposed to support a much lower estimate for the duration of the Ice Age than the 200,000 years he suggested in 1908 (Q.J.G.S., lxiv, p. 149); and he considers that the period may have ended about 10,000 years ago. Evidence is given of the presence of remains of man in the early stages of the Glacial epoch and possibly in Pliocene deposits.

II.—Characteristics of Existing Glaciers. By William Herbert Hobbs, Professor of Geology in the University of Michigan. 8vo; pp. xxiv, 301, with 34 plates and 140 text-illustrations. New York: The Macmillan Co., 1911. Price 13*s.* 6*d.* net.

In this work the general knowledge of the movements of ice and its influence in shaping many features of the earth's surface is ably expounded and admirably illustrated.

The work is divided into three parts, dealing with Mountain, Arctic, and Antarctic Glaciers; and the author dwells particularly on the distinctions, not only in size, but in origin, movements, and influence on the earth's surface, between the large continental glaciers or ice-sheets and the Alpine or mountain glaciers. As he remarks, the continental ice assumes a form the visible surface of which is largely independent of the rocky foundation on which it rests, while mountain glaciers are moulded with reference to the irregularities of their beds. In the former "no portion of the lithosphere is exposed above its higher levels. The glaciers of mountains, on the contrary, always have rock exposed above their highest levels". There are, however, small ice-cap or plateau glaciers, as in Norway and Iceland, which to some extent are transitional between the larger ice-sheets and the mountain glaciers, though more closely allied to the former because they rest on a comparatively flat foundation. In the ice-covered archipelago of Franz Josef Land the islands are almost completely snow-capped by *névé* of low density rather than by compact glacier ice, while the group of islands known as Spitzbergen exhibits inland ice, small ice-caps, and true mountain glaciers. In the references to this region (p. 111) the name of Professor Garwood should have been mentioned.

In dealing with mountain glaciers the author commences with a discussion on the origin of cirques, that are so characteristic of mountains which are or have been occupied by glaciers. In explaining their origin he supports the views of Messrs. W. D. Johnson and F. E. Matthes. Snow-banks were formed on shallow depressions of steep slopes, and by a process of 'nivation', due to frost and melting snow, rock-material was broken up and the original depression deepened. Ultimately the snow-banks assumed the functions of glaciers, and removed blocks of rock disintegrated from the walls of the cirques, which in form were at first nearly circular.

This subject is dealt with in considerable detail and is well illustrated, and it leads on to descriptions with explanations of the higher rock-features of the 'Fretted Upland', where we find various types of ridges, needles, etc. Portion of a hill-shaded map of the country between Bethesda and Llanrwst is reproduced to illustrate a 'karling' or high district dissected by cirques. Some reference is made to the influence of a glacial cover in protecting its base from ordinary weathering processes, but the author is hardly justified in speaking (in his preface) of a *school of British geologists* "which holds that the denudational effect of glacier ice is negative, because it protects the basement from the process of weathering". Various types of mountain glaciers dependent on the amount of snow supplied, or 'alimentation', are described and illustrated; and the excavation of U-shaped and hanging valleys is attributed to the widening and deepening accomplished by the ice through combined abrading and plucking processes. Attention is given to the problems of glacial sculpture in Scandinavia and other high latitudes, to the fjords or deep and now partially submerged U-valleys, that were occupied by glacier streams, the courses of which, initiated by pre-existing fractures, may also have been guided by the work of earlier rivers.

That "the Pleistocene glaciation consisted of some four distinct glacial cycles which were characterized by relatively mild climatic conditions", is regarded by the author as well recognized, though he should have added, "by some distinguished glacialists." A short account of the glacial features due mainly to deposition concludes Part I.

In Parts II and III we have descriptions of the more extensive tracts of ice in Arctic and Antarctic regions, and the physical features of the two areas are contrasted. In the one we have a polar sea surrounded by an irregular chain of land-masses, in the other a high continent massed near the South Pole. Excellent views are reproduced of the glacial features in Greenland, after Nathorst, Chamberlin, Trolle, and others. Accounts are given of the wind-drifted snow in this 'Arctic Sahara', of the various streams superglacial, englacial, and subglacial, of ice-dammed lakes, of 'submarine wells' or whirlpools of fresh water that rise at the heads of some of the fjords, and of the methods of discharge of bergs from the ice-front.

Finally, the volume includes good descriptions concerning what is known of the Antarctic Continent and its sea-ice girdle, of the marginal shelf-ice or so-called 'barrier' ice, and of the great inland ice-sheet, subjects well illustrated by views after von Drygalski, Scott, Shackleton, and others.

III.—Rock Minerals: their Chemical and Physical Characters and their Determination in Thin Sections. By Joseph P. Iddings. Second Edition. 8vo; pp. xiii + 617, 500 figures, and one coloured plate; cloth. New York, John Wiley and Sons; London, Chapman & Hall, Ltd.; 1911. Price $5.

IT is a sign of the great utility and consequent demand for this valuable technical treatise that within five years it has been necessary to issue a second edition. This edition differs from the first mainly in its greater bulk, a feature necessitated by the remarkable progress made in various departments of mineralogical science. The introductory portion, containing a general account of physical and optical characters, remains practically without change; but a very clear and not too laboured account of pleochroic haloes has been added. In this are summarized the results obtained by Mügge, Joly, and Fletcher, and a table of measurements by the two latter authors is given.

In the section devoted to the description of minerals important additions have been made with respect to nineteen species and seven groups not treated of in the previous issue of this work. Among the rare and recently discovered minerals concerning which particulars are given may be noted carnegieite and rhönite. The groups referred to are designated respectively by the names of the minerals melanocerite, columbite, samarskite, æschenite, aragonite, barite, and triphyllite. The systematization of hitherto unassociated details given therein will undoubtedly be of considerable value to students. In the interests of terminological accuracy it might have been well in the description of minerals to substitute the word alstonite for bromlite, the latter designation owing its origin to a misspelling of the name of the locality Brownley Hill.

An excellent birefringence diagram has been added to the tables and plate of interference colours at the end of the book. There can be no doubt that this volume, brought up to date as it is with scrupulous accuracy and attention to the requirements of students of petrography, cannot fail fully to maintain its high position among the premier treatises on mineralogical science.

REPORTS AND PROCEEDINGS.

Geological Society of London.

November 8, 1911.—Professor W. W. Watts, Sc.D., LL.D., M.Sc., F.R.S., President, in the Chair.

The following communications were read:—

1. "On the Interglacial Gravel Beds of the Isle of Wight and the South of England, and the Conditions of their Formation." By Professor Edward Hull, M.A., LL.D., F.R.S., F.G.S.

The author, after referring to the investigations of previous authors, especially of Mr. Codrington and the officers of the Geological Survey, with which he in the main agrees, points out that the origin and mode of formation of the gravel terraces of the Isle of Wight and the New Forest districts are still open to discussion. He points out that the levels of the higher beds on both sides of the Solent up to about 400 feet indicate the amount of subsidence of the whole area at a time when the stratified gravels, composed mainly of rolled flints, were formed at the margin of the uprising ridges of the Chalk in the post-Glacial epoch, for this part of England. Preceding this was the great uplift indicated by Godwin-Austen, by which the British Isles were joined to the Continent as land. By this uplift the English Channel was laid dry, and along its centre there ran a river from its source about the Straits of Dover to its outlet into the ocean through the Continental Platform. This river-channel is laid down on the Admiralty Charts under the name of 'the Hurd Deep' for a distance of 30 miles of its course, and has been named by the author 'the English Channel River'. The author considers the gravel beds of this district to be the representatives of the High-level Gravels of the Midlands and Cromer, also of the 'Interglacial Gravels' of Cheshire and Lancashire, and the shell-bearing beds of the Denbighshire Hills, and of Moel Tryfaen in Wales, at levels of about 1,200 feet above the sea.

2. "The Gopeng Beds of Kinta (Federated Malay States)." By John Brooke Scrivenor, M.A., F.G.S.

The paper as originally presented was the outcome of field-work done chiefly in 1910; but, as it had to be held over until the November session, an appendix has been added giving additional evidence supporting the author's views and more information about the extent of the Gopeng Beds.

Gopeng is a prosperous mining centre in the Kinta Valley, close to the granite of the main range of the Malay Peninsula. The following is the succession of the rocks:—

Youngest.	The Mesozoic granite, with its modifications and veins.
	Phyllites and quartzites.
	The Gopeng Beds.
Oldest .	Crystalline limestone (Carboniferous or Permo-Carboniferous).

The physical features of the country are described, and it is shown that not only are the Gopeng Beds cut by veins from the granite and altered at the junction with the granite, but they are also faulted down against the limestone, which forms precipitous hills.

The Gopeng Beds, consisting of clays and boulder-clays with some stratified drift, are of glacial origin. This is proved by the inclusion of large boulders in the clay, by the physical condition of the components of the clays and their distribution, and by the striking resemblance of the beds as a whole to Pleistocene glacial detritus.

The nature of the beds is considered to be sufficient proof of glacial origin, but it is admitted that no boulders have been found showing striation due to ice-action, nor has any glaciated rock-surface been found. Such evidence, however, can hardly be expected, because the boulders are all more or less decomposed owing to the great power of the ground-water in removing silica; and, if the limestone ever presented the features of a glaciated surface, it has been so much modified by solution owing to the action of ground-water since then, that all traces of those features must have disappeared. Large unweathered boulders of corundum are present in some of the beds, but their hardness would make the appearance of ice-scratches improbable.

Unfortunately the pale and uniform colouring of the bulk of the clays and boulder-clays makes it hard to obtain photographs showing clearly the resemblance to Pleistocene glacial deposits. A number of photographs is submitted, however, that will, it is hoped, do something towards this. The petrology of the Gopeng Beds is described in detail. The most interesting point revealed is that the ice from which the detritus was derived passed over a stanniferous granite mass, and in consequence the Gopeng Beds carry tin-ore throughout, though sometimes in very small quantities. This tin-ore is an original constituent of the beds, but they have been further enriched by tin-ore derived from the Mesozoic granite at their junction with the granite and in the neighbourhood of veins from the granite that have risen through the limestone.

The faulting in the Gopeng neighbourhood, the general structure of the country, and the age and origin of the Gopeng Beds are discussed in detail. The Gopeng Beds are considered to be the equivalent in time of the Talchir boulder-beds of Orissa; but a petrological similarity is wanting, because the Gopeng Beds were derived from a mass of stanniferous granite, the position of which is at present unknown.

CORRESPONDENCE.

THE CULM-MEASURES OF THE EXETER DISTRICT.

Sir,—In the last number of the Geological Magazine, pp. 495–7, Mr. Arber, when criticizing Mr. F. G. Collins for doing things he has not done, and for omitting others that he has done, has allowed himself to commit a double error.

It is clear from a glance at Mr. Collins's paper[1] that the words Mr. Arber quotes, and to which he objects, are not those of Mr. Collins at all; they relate solely to the fauna which Mr. Crick

[1] Quart. Journ. Geol. Soc., vol. lxxvii, pt. iii, p. 393, 1911.

has so admirably worked out and described in his notes (loc. cit., pp. 399–413).

Mr. Collins has made a good beginning by finding a useful fauna in a difficult area; and by carefully recording the location of the specimens he has laid the foundations of a more detailed knowledge of these rocks in the only possible way. He wisely commits himself to no conclusions at present. When he has done more work on the same lines, with the assistance of his palæontological friends, he may be able to throw some light on the detailed stratigraphy of the area; even if he does not, he will at least have given us something firmer to build upon than those lithological resemblances on which Mr. Arber has to place so much reliance.

C. Davies Sherborn.
J. Allen Howe.

THE ZONAL CLASSIFICATION OF THE TRIMINGHAM CHALK.

Sir,—In his Presidential address this year to the Malacological Society Mr. R. B. Newton quoted my statement in 1908 that "hence the zone of Chalk at Trimingham, lying above the zone of *Belemnitella mucronata*, now divided and defined by me for the first time, requires a name", and inferred from those words that I had forgotten my own proposal in 1906 to establish a zone of *Terebratulina gracilis* and *T. Gisei* for this Chalk. This is a misconstruction, but one to which I have laid myself fairly open by excessive brevity. The facts are that in the original paper of 1908 I stated that my opinion was unaltered (it still is unaltered) that *T. gracilis* and *T. Gisei* were far superior to any other fossil or assemblage of fossils both for defining the zone and for labelling it. My editor said, "You had better leave that out: they will never adopt it," and the statement quoted by Mr. Newton was settled to take its place. It was intended to bear the construction that two opposite views as to the best definition and label of a zone embracing the Chalk of Trimingham being on record, with a detailed account of the palæontology of the numerous divisions of that Chalk, the question is ripe for the final tribunal on such questions, i.e. the consensus of textbook-writers, to which it must be left. It does not follow that either view will succeed.

R. M. Brydone.

November 18, 1911.

OBITUARY.

Deaths are announced, on September 25 of Auguste Michel-Lévy, Director of the Geological Survey of France; on August 6 of Dr Florentino Ameghino, Director of the Museum at Buenos Aires; and on June 5 of Dr. Victor Carl Uhlig, Professor of Geology in the University of Vienna. Suitable Notices will appear later on.

MISCELLANEOUS.

Zoological Address-book.—A second edition of the *Zoologisches Adressbuch* has just been issued for the German Zoological Society by Friedlaender and Sohn for seventeen marks bound. It is a bulky volume of 1110 pages, and from the careful manner in which people in this country are circularized should be found of great service. Universities, Academies, and Societies are included, and the total number of names listed reaches the astonishing total of 17,800, all forming one index at the end. The book will appeal to geologists as well as zoologists, for palæontologists are included. Errors can be found, but what book of this nature is free from them? and such errors are frequently due to the indolence of those receiving the circular in not troubling to return it to the publishers.

Anthrapalæmon Grossarti, Salter, 1861, Rochdale: A Correction.—In the August Number of the Geological Magazine, pp. 361–6, 1911, I published an account of the genus *Anthrapalæmon*, and figured a very beautiful carapace from Sparth, Rochdale, which I stated was obtained by Mr. Fred Holt in 1907. In this I find I was in error, as the specimen in question was found by Mr. H. Howard, of Rochdale, but was sent to me by Mr. Holt. This applies also to the fragmentary specimen of a scorpion, *Eobuthus holti*, Pocock (Mon. Pal. Soc., 1910, p. 14, pl. ii, fig. 2), which I had placed in Mr. Pocock's hands to describe. I regret that I overlooked the fact that both the above specimens were obtained by Mr. Harold Howard. Mr. Howard also mentions that in Mr. Baldwin's article on some "Fossil Myriopods from Rochdale" the writer refers to one *Euphoberia* (Geol. Mag., p. 78, February, 1911) as having been found by Mr. F. Howard: this should read Mr. H. Howard.—H. W.

Our Future Coal Supply.—Mr. McKenna (Home Secretary) on October 30 issued the following statement: "I have seen a report of the address delivered by the President of the British Association, but I observe that the President's forecast of the probable duration of the coal supplies of the country does not take into consideration certain factors which have an important bearing on the question. In the first place, the President's estimate took no account of the large amount of coal in fields unproved at the time of the inquiry of the Royal Commission, nor of the amount of coal lying below the depth of 4,000 feet, which the Commission took to be the present limit of workable coal, but which it may be found possible hereafter to exceed. These two sources the Commission estimated at over 39,000 and 5,000 million tons respectively, or together nearly half as much as the amount of coal estimated to exist in the proved coal-fields. In the second place, the President's estimate was based on the assumption that the output of coal would continue, at any rate for some time, to increase at the same rate as in the past. The Commission, on the other hand, considered that at a time not far distant the rate of increase of output would become slower, to be followed by a period of stationary output, and then a gradual decline. No recommendation was made by the Royal Commission, who reviewed the whole subject at length as to action with a view to preventing waste in the working and using of coals. The suggestion which Sir W. Ramsay is reported to have made, that Parliament should impose a penalty on wasteful expenditure of energy supplies, would involve an amount of control over the industries of the country which under present conditions it would be impossible for any Government to undertake. The Commission looked forward to the introduction of considerable economies in the future, and I am advised that both in the working and in the using of coal progress is being made in this direction. As regards the question of the export of coal, the Commission reported that the witnesses whom they heard were generally of opinion that 'the maintenance of a large coal export trade is of supreme importance to the country, and essential to the prosperity of the coal-producing districts', and the Commission saw 'no present necessity to restrict artificially the export of coal in order to conserve it for our home supply'."—*Morning Post*, October 31.

Discovery of Flint Implements beneath the Red Crag in Suffolk.—Sir E. Ray Lankester, F.R.S., read a paper before the Royal Society, November 16, 1911, on "The Discovery of a Novel Type of Flint Implements from below the Base of the Red Crag of Suffolk, etc." Flint implements of human manufacture have been discovered by Mr. J. Reid Moir, of Ipswich, in the detritus-beds at the base of the Red Crag in Suffolk and by Mr. W. G. Clarke at the base of the Norwich Crag in Norfolk. These implements are of a novel type—the 'rostro-carinate' or 'eagle's beak'—but include also scrapers, hammers, and large one-sided picks. They do not include any forms resembling the Chellian and Acheuilian ovate implements. The Sub-crag type (rostro-carinate) is essentially compressed from side to side. The Chellian and Acheuilian and Moustierian types are essentially depressed or flattened like a leaf. The race of men who manufactured the Sub-crag flint implements probably lived on the land surface not remote from the sea, during the period of the Coralline Crag, which was characterized by a warmer climate than that of the Red Crag, and may justly be regarded as marking the close of Pliocene conditions in this part of Europe. The land barrier joining Britain to Scandinavia, which had kept the southern part of what is now the North Sea from access of cold northern waters ever since the earliest Tertiary period, disappeared at the beginning of the deposition of the Red Crag.

Errata.

In Dr. Fermor's paper ("What is Laterite?"), table at p. 514, 3rd col., last line but two, *for* mixed *read* veined.

In our notice of Admiral De Horsey's work (p. 524) we have inadvertently printed the title as *Draysoniana*: it should be *Draysonia*.

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