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"THE GEOLOGIST".

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EDITED BY

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AND
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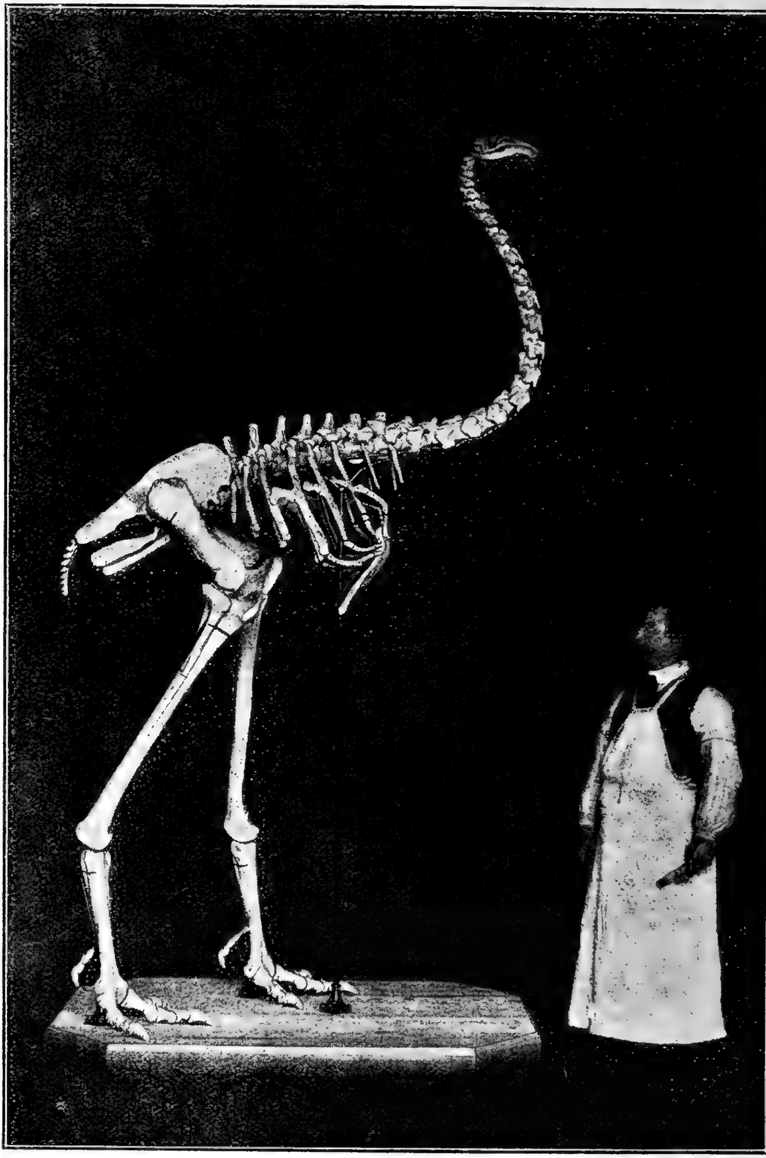

THE

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NEW SERIES. DECADE V. VOL. VII.

No. I.—JANUARY, 1910.

ORIGINAL ARTICLES.

I.—On Olivine Nodules in the Basalt of Calton Hill, Derbyshire.

By H. H. Arnold-Bemrose, J.P., Sc.D., F.G.S.

(PLATES I AND II.)

Introduction.

THE object of this paper is to place on record the occurrence of olivine nodules in a British basalt which, though closely allied in structure to some of the Tertiary basalts of the Continent, belongs undoubtedly to the Carboniferous age. Olivine nodules frequently occur in the Continental basalts and have been considered by some writers as inclusions of peridotites, but by others as segregations from the magma.

I can find no description of olivine nodules from any British basalt in which the olivine is in a fresh condition. The nearest approach to such a nodule is that described by Mr. S. Allport, from Ballybrood, in the county of Limerick.[1] The rock, he says, "contains small patches of red and green serpentine scattered through it." "In one of the largest patches there are several grains of olivine, and an examination in polarized light shows that it was originally a nest of olivine which has been almost completely altered to serpentine."

Dr. Teall,[2] in referring to Mr. Allport's description, remarks that "this is an extremely important observation, because it is the only one yet made of the occurrence of anything like an olivine nodule in any British basalt".

In 1894, in describing a basalt from Calton Hill, Derbyshire, I mentioned the presence of olivine in small groups or nests of crystals[3]; and in 1907 I stated that I had found olivine in small nests of bottle-green colours.[4] The largest nest of olivine and augite then found by me measured only $2{\cdot}7 \times 2{\cdot}2$ mm. under the microscope.

Trial holes have recently been made in Calton Hill, Derbyshire, which is a volcanic vent of Carboniferous age, and a level has been

[1] "On the Microscopic Structure and Composition of British Carboniferous Dolerites": Q.J.G.S., 1874, vol. xxx, p. 552.
[2] *British Petrography*, 1888, p. 246.
[3] Q.J.G.S., 1894, vol. l, p. 621.
[4] Q.J.G.S., 1907, vol. lxiii, p. 252.

driven through the agglomerate on the northern slope of the hill into the basalt. It has, therefore, been possible for me not only to examine the relationship between the agglomerate and basalt, but also numerous blocks of the basalt, many of which contain olivine nodules. The largest nodule I have found is $2\frac{1}{4}$ inches in length, and from one trial hole I obtained forty-nine nodules in less than an hour.

In the level, which is about 50 feet in length, the agglomerate is at first in horizontal beds. Further into the hill the beds dip to the south. The dip increases until it becomes nearly vertical at the junction between the agglomerate and basalt. The agglomerate varies in coarseness and consists of basalt lapilli either in a limestone paste or in a volcanic detritus. The former kind is very similar to the agglomerate of Ember Lane, near Bonsall. The agglomerate of Calton Hill contains lumps of limestone, which are often more or less marmorized, pieces of basalt and inclusions of silica and calcite, which are several inches in length. Two thin slices of these inclusions were examined. They consist of crystalline calcite and of quartz grains, in the form of a mosaic, and are probably a secondary aggregate of quartz and calcite.

The Basalt of Calton Hill

consists of olivine and big augite phenocrysts in a groundmass of small felspar laths, augite grains, and prisms, and magnetite or ilmenite. The felspars and augite prisms often show a well-marked flow-structure. The constituents of the rock are generally in a fresh condition. The olivine, which is sometimes altered to serpentine along the cracks, occurs in phenocrysts and in groups of phenocrysts, and in irregularly shaped grains. The augite appears as large phenocrysts, often showing hour-glass structure, and sometimes containing portions of the groundmass, and in small prisms and grains. Both olivine and augite are found together in small nests or groups of crystals. The felspars sometimes occur in two generations and often exhibit a flow-structure.

The Nodules.

The distribution of the nodules is general throughout the basalt of Calton Hill. In a hand-specimen they are easily distinguished and appear as a crystalline aggregate of bottle-green and yellow olivine with dark augite in the fine-grained and nearly black basalt. Some of the nodules are in a very fresh state; in others the cementing material between the grains has been dissolved away and the small grains may easily be separated by the finger. The nodules consist mainly of olivine, but contain a fair proportion of augite, and in some cases a small quantity of picotite. These minerals occur in irregularly shaped grains without any crystalline boundary, except in very few instances, especially near the outside of a nodule. The grains are not deformed crystals, but have hindered one another's development as far as crystalline boundary is concerned. Fourteen thin slices from the nodules were examined.

The olivine in the nodules is often traversed by cracks containing serpentine, and in some cases calcite and oxide of iron. Otherwise this mineral is in an unaltered condition. It sometimes contains

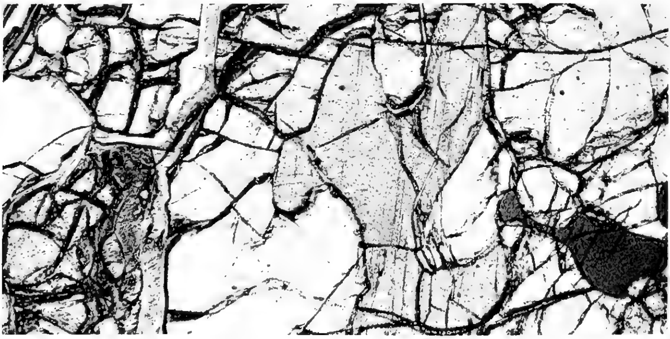


FIG. 1. X20

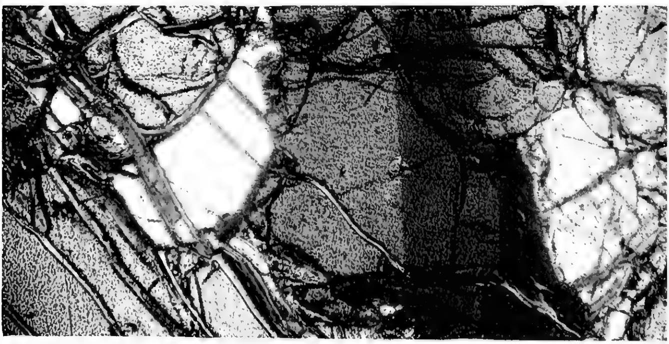


FIG. 2. X20

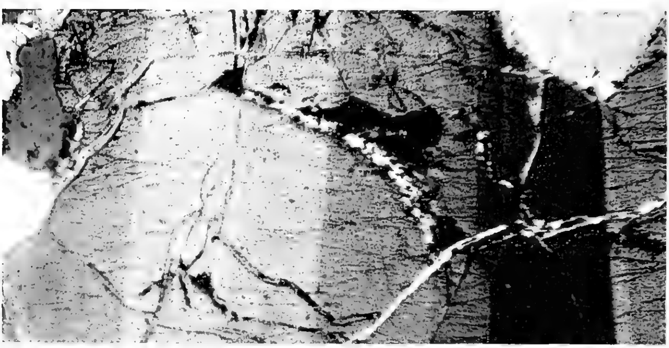


FIG. 3. X20

H.A.B., Photomicro. *Bemrose, Collo.*

Olivine Nodules in Basalt.

Calton Hill, Derbyshire.

inclusions which give it a very rough appearance under the microscope. Some of the olivine grains are twinned many times. One twin in thin slice 1479 consists of twelve portions, another consists of five parts. It is almost impossible to distinguish the boundaries of the twins in ordinary light, but in polarized light the whole or part of a grain is divided into broad plates which differ little from each other in colour, the sides of which, corresponding to the trace of the twinning planes are often, but not always, parallel to one another. The angles of extinction of adjacent portions differ only by a few degrees and extinction in all cases is either parallel or nearly parallel to the trace of the twinning planes.

The pyroxene in the nodules is monoclinic and can only be referred to augite. In the absence of crystallographic outlines the only method of distinguishing between the orthorhombic and monoclinic pyroxenes is to measure the angles of extinction with regard to the cleavages and to observe the optic figures in convergent light. In the thin slices examined there is no certain trace of enstatite or orthorhombic pyroxene. On the other hand, the whole of the evidence points to the presence of monoclinic pyroxene or augite. Two types of cases occur in which the crystalline grain is traversed by parallel cleavage lines. In the one extinction takes place parallel to the traces of cleavage and in convergent light shows an optic axis just outside the field of view. These are augite grains parallel to (100). In the other the angle of extinction varies from a few degrees up to an angle of 45° and denotes augite from the prism zone. Few cases are present of pyroxene showing an almost rectangular cleavage, but in all these there is an optic axis nearly in the centre of the field, which proves that the mineral is augite and not enstatite.

Picotite is present in the nodules only to a slight extent. It is of a yellowish-brown colour in ordinary light and becomes extinct under crossed nicols.

The presence of olivine and of augite in small groups from almost microscopic dimensions up to a length of more than two inches in the Calton Hill basalt is in favour of the nodules being segregations from the magma and not enclosures of older rock.

EXPLANATION OF PLATES I AND II.

[The figures were photographed by the author from the microscope, under polarized light with crossed nicols.]

Plate I.

Fig. 1. Thin slice (1464), magnified twenty diameters, showing olivine grains in a nodule. The olivine is traversed by cracks containing serpentine and minute pieces of black iron ore.

Fig. 2. Thin slice (1464), magnified twenty diameters, showing olivine grains in a nodule. The grain of olivine near the centre of the figure is twinned; one portion of the twin extinguishes parallel to the trace of the twinning plane and the other at an angle of 4° with it.

Fig. 3. Thin slice (1479), magnified twenty diameters, showing part of a large grain of olivine in a nodule. The olivine is traversed by cracks and shows multiple twinning. The twinning planes are not always parallel, and the extinction angle of each portion of the twin is either parallel or nearly parallel to the trace of the twinning plane.

PLATE II.

FIG. 1. Thin slice (1459), magnified fifteen diameters. The two large dark grains with parallel cleavage lines are augite. That on the left extinguishes parallel to the cleavage and shows in convergent light an optic axis just outside the field of view, and is, therefore, parallel to (100). The lighter one at the left-hand bottom portion of the figure extinguishes at an angle of 5° with the cleavage cracks and shows only a slight trace of an axial figure. To the left and the right are several olivine grains. At the right-hand top corner is a small portion of the basalt in which the nodule occurs.

FIG. 2. Thin slice (1459), magnified twenty diameters, showing the junction between a nodule and the basalt in which it occurs. In the nodule, in the upper part of the figure, olivine and augite are seen, and in the lower part the flow-structure of the felspar microlites in the basalt.

FIG. 3. Thin slice (76), magnified fifteen diameters. Basalt containing phenocrysts of augite and olivine in a groundmass of felspar microlites of magnetite and glass. The big crystal of augite, to the left, contains inclusions from the groundmass zonally arranged. On the right is a small phenocryst of olivine.

II.—NOTES ON NEW OR IMPERFECTLY KNOWN CHALK POLYZOA.

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

(PLATE III.)

(*Continued from Vol. VI, p.* 400.)

MEMBRANIPORA HUMILIATA, nov. Pl. III, Figs. 1–3.

Zoarium always adherent.

Zoœcia generally elongated, but very variable in shape and dimensions; length of area ·68 to ·48 mm., breadth of area ·36 to ·2 mm.; no front wall, side walls very low, with a further depression at the head of the zoœcium, and furnished all round with slender buttresses, which are much more easily distinguished in the upper part of the zoœcium, owing to their greater size and projection there, than in the lower part.

Oœcia semi-elliptical in outline, relatively very small, very frequently present, very brittle and especially so when associated with avicularia, so that zoœcia with typical arrangement of perfect oœcium succeeded by avicularium are exceedingly rare.

Avicularia accessory, small oval rings lying at the head of the zoœcium and normally symmetrically above the oœcium when present, but sometimes beside it.

The species is easily distinguished by the abnormal shallowness of the zoœcia, which makes specimens look to the naked eye like much-worn remains of other species, and causes such inequalities in the underlying surface as the smaller tubercles of *Echinocorys*, which would be out of sight at the bottom of zoœcia of normal depth, to show up most prominently.

Fairly common at Trimingham.

MEMBRANIPORA ANTERIDES, nov. Pl. III, Figs. 4–6.

Zoarium always adherent.

Zoœcia pyriform with subtriangular area and considerable extent of front wall below it; length of area ·32–·36 mm., width of area ·2–·24 mm.; side walls supported by buttresses; at the head of the

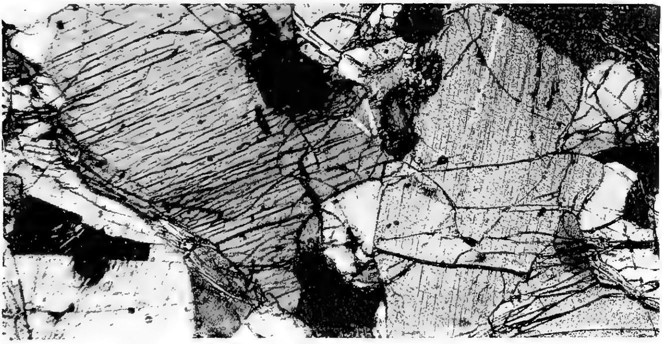


Fig. 1. X15

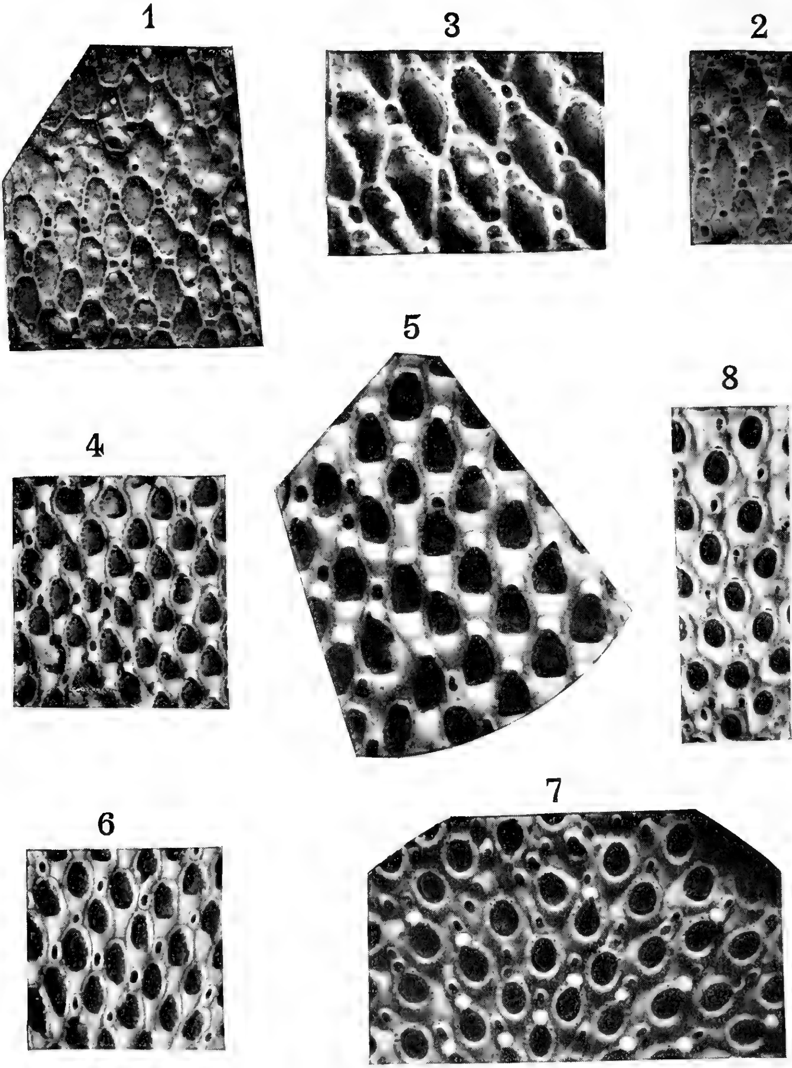
Fig. 2. X20

Fig. 3. X15

H.A.B., *Photomicro.* Bemrose, *Collo.*

Olivine Nodules in Basalt.

Calton Hill, Derbyshire.



R. M. Brydone photo.

Chalk Polyzoa (Bryozoa).

zoœcium there is generally in the central line a buttress distinctly bigger than the others, with a considerable interval on either side of it. The zoœcia are much deeper than those of *M. humiliata*, though still on the shallow side, and their edges are wrinkled, but so faintly that it is only clearly discernible with the larger magnification.

Oœcia more globose than those of *M. humiliata*.

Avicularia very similar to those of *M. humiliata*.

The typical arrangement of the oœcium and avicularium is the same as in *M. humiliata*, but while they never lie side by side, in one instance two avicularia have been found to one zoœcium, which arrangement is at present unknown in *M. humiliata*.

Not uncommon at Trimingham.

The system of buttressed walls which this species shares with *M. humiliata* marks them off clearly from all other Cretaceous *Membraniporæ*, but the typical arrangement of avicularium above oœcium links them, probably only superficially, with *M. Griffithi* and *M. Trimminghamensis*.

Membranipora Trimminghamensis, mihi. Pl. III, Figs. 7 and 8.

I take this opportunity of supplementing from photographs of the type-specimen the figure given with the original description. Further study has shown that the two upper pairs of granules are perforate and the oœcia are shaped like an inverted water-bottle, the expanded lip curving round and practically hiding the uppermost pair of granules, which are smaller than the succeeding pair. Length of area ·36 mm., width ·28 mm.

In describing this species (the specific name of which should have been spelt *Triminghamensis*) and *M. Griffithi* I omitted to discuss *Cellepora trifaria*, Hag.,[1] which shows a similar arrangement of oœcium and avicularium, relying perhaps overmuch on the facts that Marsson did not refind such a form at Rugen, and did not find the species recognizable in Hagenow's collection. The figure appears to be taken from a worn specimen, which might equally well be *M. Griffithi*, *M. Triminghamensis*, or some other species. The description only adds the feature of possessing large earshaped avicularia; and these separate it as well from *M. Triminghamensis*, which has no large avicularia, as from *M. Griffithi*, which has symmetrical large avicularia, while the ear is decidedly unsymmetrical. *Cellepora trifaria* cannot therefore be treated as a valid anticipation of either of the other species.

EXPLANATION OF PLATE III.

Fig. 1. *Membranipora humiliata*. × 20.
,, 2. Ditto, another specimen showing perfect oœcium associated with avicularium in typical arrangement. × 20.
,, 3. Ditto. × 40.
,, 4. *Membranipora anterides*. × 20.
,, 5. Ditto. × 40.
,, 6. Ditto, another specimen with the buttresses showing dark against white chalk. × 20.
,, 7. *Membranipora Triminghamensis*, type-specimen. × 20.
,, 8. Ditto, type-specimen, lighted to show bar across perfect avicularia. × 20.

[1] Geinitz, *Grundriss der Versteinerungskunde*, p. 617, pl. xxiii *b*, fig. 40.

III.—Notes on the Æolian Deposits on the Coast at Étel, Morbihan. Part I.

By Rev. R. Ashington Bullen, B.A.Lond., F.L.S., F.G.S., etc.

(PLATE IV.)

§ 1. Étel: Introduction.
§ 2. Raised Beach recently exposed.
§ 3. The Granulitic Rock.
§ 4. Traces of Post-Neolithic Submergence.
§ 5. General remarks on the direction of the Rivière d'Étel, near the sea.
§ 6. The present Terrace Beach of pea-sized gravel.
§ 7. The four Terraces on the seaward side, and their flora.
§ 8. The Æolian Transport of Sand, etc., to form the Dunes.
§ 9. Marine species contributing materials for dune formation, especially Mollusca.
§ 10. Analysis of the Dune Sand.
§ 11. Need of further work on Sand-dunes.

§ 1. Étel is situated on the west of the Megalithic district of which Carnac is the centre. It stands about 2 kilometres from the sea on the Rivière d'Étel. This so-called river is really an arm of the sea, which drains the extensive estuarine basin to the north-east, which is, in its way, almost another Morbihan (Little Sea) similar to the well-known one farther east. The tide rushes into the latter at a rate of from 7 to 11 knots per hour, at neap and spring tides respectively, and its ingress into and egress from the Rivière d'Étel cannot be much less. M. P. Le Strat, who has been much at sea in different parts of the world, considered that the incoming tide was rushing in at a rate of 7 or 8 knots an hour under the bridge of Lorrois, where the river narrows, when we passed it on October 11, 1909. The channel of the Rivière d'Étel is thus kept permanently open, and ships of from 50 to 150 tons are engaged in the tunny fishery and smaller boats in the sardine trade. Messrs. Peneau have a sardine-curing establishment at La Magoire, just opposite, across the river (Diagram, Text-fig. 1, p. 7).

An expert naval officer kindly furnishes the following information:—

(1) The rate the tide enters the Rivière d'Étel is 4 knots on the flood and it leaves at 5 on the ebb at spring tides. The latter, under special circumstances, might be more, but the amount the sailing directions give is the usual rate.

(2) The depth in the navigable channel is from 3½ to 8 fathoms.

(3) The depth on the bar is about 1 foot at lowest water. The rise of water above this is, springs 16 or 17 feet, neaps 12 or 13 feet.

(4) The bar has been known to dry as much as 8 feet at low-water. The wind also causes it to shift.

(5) A hurricane blows from 80 to 100 miles an hour. The pressure at the latter speed is 49·2 lb. per square foot.

§ 2. Quite recently the road to the beach at the point marked (×) in the map, has been widened, and the clear perpendicular section reveals a Raised Beach, the base of which is about 15 feet above high-water mark, which probably, at the recent spring tide early in October (7th) last, reached its maximum, as it was aided by strong gales. The section of the Raised Beach now exposed shows a thickness of 2 ft. 3 in. to 2 ft. 6 in. It consists of well-rounded pebbles of opaque-milky, transparent, or fibrous quartz, stained a deep red, together with what is probably Lydian Stone: but these rocks must form the subject of a second part of this paper. This raised beach

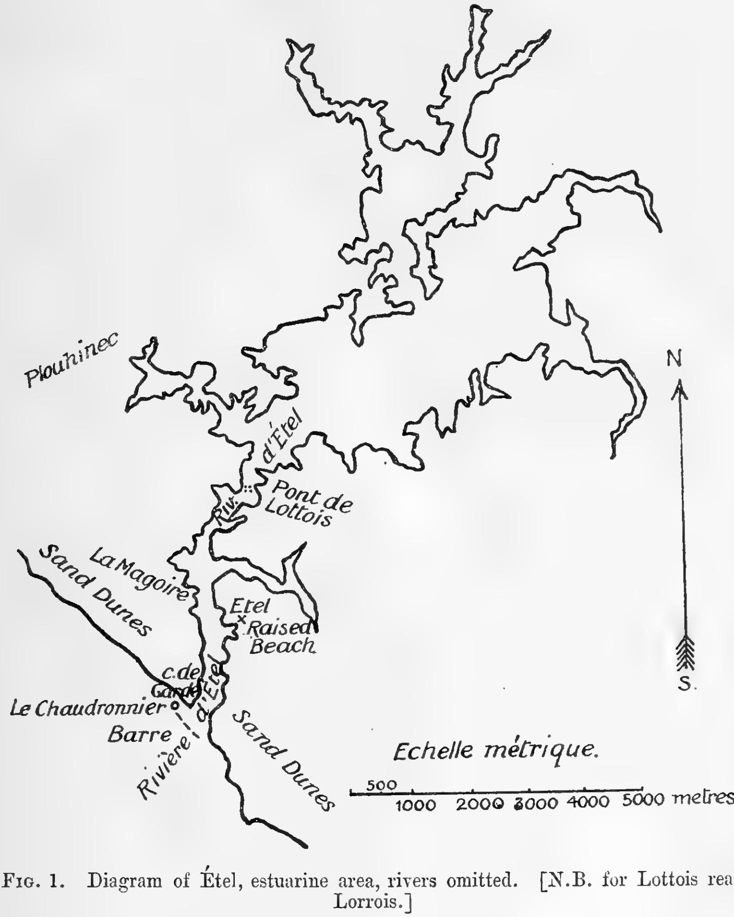


FIG. 1. Diagram of Étel, estuarine area, rivers omitted. [N.B. for Lottois read Lorrois.]

is overlain by from $3\frac{1}{2}$ to 4 feet of very dark brown, vegetable, peaty-looking mould, irregularly and sparsely scattered in the lower half of which are similar raised-beach pebbles (Text-fig. 2). Unfortunately, the rest of the Raised Beach on the other side of the road has been quarried away, but the section that remains above the solid granulite contains a few scattered pebbles. No local granulitic pebbles occur in the Raised Beach, although some angular granulitic fragments do occur in the 'overburden' of mould. After careful examination no marine shells, fragmentary or otherwise, were to be seen in the Raised Beach. The absence of local stone in the Raised Beach itself is noteworthy. The raised beaches of this region must have been formerly very extensive, judging by the vast number of derived pebbles of the same materials to be found on the present beach at Étel and elsewhere, and on the exposed point near the *barre* on the left bank of the river.

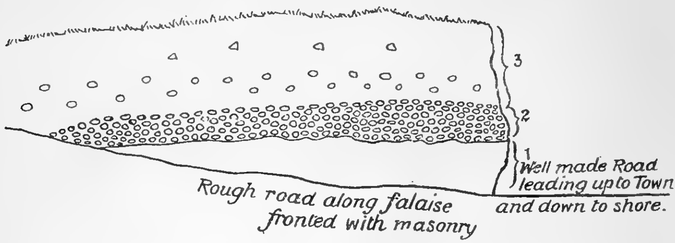


FIG. 2. Raised beach quarried away on east side of road.

1. Granulite: about 2 ft. 6 in. in deepest exposure.
2. Raised beach: resting directly on the solid rock, 2 ft. 3 in. to 2 ft. 6 in.
3. 'Head': with occasional subangular granulite in its upper part and scattered pebbles in its lower, 3 ft. 6 in. to 4 feet, mould dark-brown peaty colour.

§ 3. The underlying rock of the place is 'granulite' (using the term in its French sense). "La granulite forme trois trainées principales, toutes dirigées à 104° et par suites parallèles entre elles. La première (trainée de Locronan), très étendue sur les feuilles voisines, ne forme que le coin N.E. de la feuille; la seconde (trainée de Rosporden) s'étend de Trévoux à Inzinzac; la troisième (trainée de Port-Louis) s'étend des Îles Glenan à Etel . . . la granulite de la 3ième trainée est plus franche (de la structure feuilletée) plus massive et à plus gros grains, dans les falaises des Glenans, de Ploemeur, de Port-Louis et de Gavre; sphène, mica noir très épigenisé en mica blanc, mica blanc, oligoclase, orthose, microcline, quartz." [1] Grains of mica are plentiful in the present beach-sand and in the blown-sand of the dunes, thus showing that the blown-sand is derived from the present beach.

Between the Îles Glenan, 60 kilometres to the west of Étel and the mainland, the trawl brings up large pebbles of granite and porphyry, which belong to the raised beaches of the region. But the rolled pebbles that are found in the *grèves* of Plouhinec (5 miles from Étel westward) and behind the sand-dunes seem to have been derived from a different district from the pebbles of the Glenan area.

According to the French survey the district between the Blavet and Étel Rivers bears traces of a vast and ancient estuary.[2]

§ 4. Large masses of peat, some $1\frac{1}{2}$ to 2 feet across, and about 3 inches thick, one rolled into a rounded peat 'boulder', occurred on the sea face of the coast, near the 'Chaudronnier' or 'Pierre d'Étel' (see Diagram 3), and these, derived from some submarine area, coupled

[1] Note explicative, Sheet 88, Carte Géologique détaillée de Bretagne. Note explicative, Sheet 89, Carte Géol. det. "Cette granulite . . . continue de Port-Louis à la Rivière d'Auray." Mr. F. H. Butler points out that the French 'granulite' is equivalent to the fine-grained muscovite-biotite granite of English petrologists (*vide* Harker, *Petrology for Students*).

[2] Ibid.

with the 'Dolmen-sous-marin' overgrown with seaweed, near Carnac-Plage and others elsewhere, point to a movement of subsidence, in or after Neolithic times, and posterior to the Raised Beach epoch, similar to that of the British Isles.[1] (See Plate IV, Fig. 1.)

§ 5. The course of the Rivière d'Étel from Étel to the sea is almost due north to south, and is undoubtedly due to the underlying granulite, which crops out at the Lighthouse point with a slight orientation to the south-east, and a dip to the east. We were exceptionally favoured with a violent gale on October 8, 1909, so that the action of the prevailing south-west wind could be well observed. The sea broke with unceasing fury on the granulite mass, one large rock of which standing close in-shore, the Pierre d'Étel, well named the 'Chaudronnier', on which a beacon is built, was in a constant smother of water and at times invisible. There is a ladder up the beacon, but the chance of any swimmer reaching it would be very small. The lighthouse is built on the solid land farther in from the sea.

On this side of the river (the right), for 12 kilometres, stretch dunes of blown-sand, used by the French Government for testing the heaviest artillery, occasionally with fatal results to indiscreet explorers. Last year (1908) an ancient building, rather primitive, was unearthed about a kilometre south of La Magoire. The Curé of Plouhinec considers that this is an old chapel of Ste. Brigitte, the church of a small settlement of poor fishermen, burnt down during some raid. It was surrounded by burials, but so far I have been unable to learn any more about its age. The sand-dune which covered it being cleared away, much charred wood was found and some interments. There are no modern buildings near it; the sand has now entire possession of the place (Diagram, Text-fig. 3, p. 10).

Judging by the size of some of the lichens, these dunes have not greatly increased inland for several years, any increase probably taking place along the sea-edge of the area. The absence of pebbles on this series of dunes is remarkable, and also the fineness of the sand.

The natural effect of the south-west wind would be to bend the mouth of the river to the south-east, but the strong scour of the incoming and outgoing tide is such that the contour of the banks is not altered nor is there anything at the mouth in the nature of a 'fleet', and the *barre* across the entrance can be sailed over at all suitable times of tide.

§ 6. Passing now to the consideration of the east or left bank of the Rivière d'Étel, near its mouth, along the edge fretted by the waves (which is a somewhat coarse quartz sand), we find that above the tide-mark landward, for a distance of some 200 yards in breadth, the beach material is a quartz gravel of well-worn oval or round pebbles, mostly varying from the size of a pea to a small French bean, out of which small gravel everything has been riddled, seemingly by the action of the prevalent south-west wind.

There are occasional lines of large white gravel, resembling the stones of the Raised Beach (×) before described. (Text-fig. 1, p. 7.)

[1] See Prestwich, *Geology*, vol. xi, p. 525; Q.J.G.S., 1892, vol. xlviii, p. 304. Also "Les Megalithes submergés des Côtes de Vendée", par Dr. Marcel Baudouin: *L'Homme Préhistorique*, 1er Mai, 1905, No. v, pp. 130–48.

The small pea-sized gravel underlying these lines of stones predominates. It is noteworthy that the same sort of gravel occurs at Constantine Island, Cornwall, as a Raised Beach[1] underneath the blown-sand, and on which the prehistoric, probably Neolithic, oblong 'potter's house' (discovered by Mr. Harold Hellyar, of Harlyn) used to exist before it was ruthlessly destroyed in 1902.

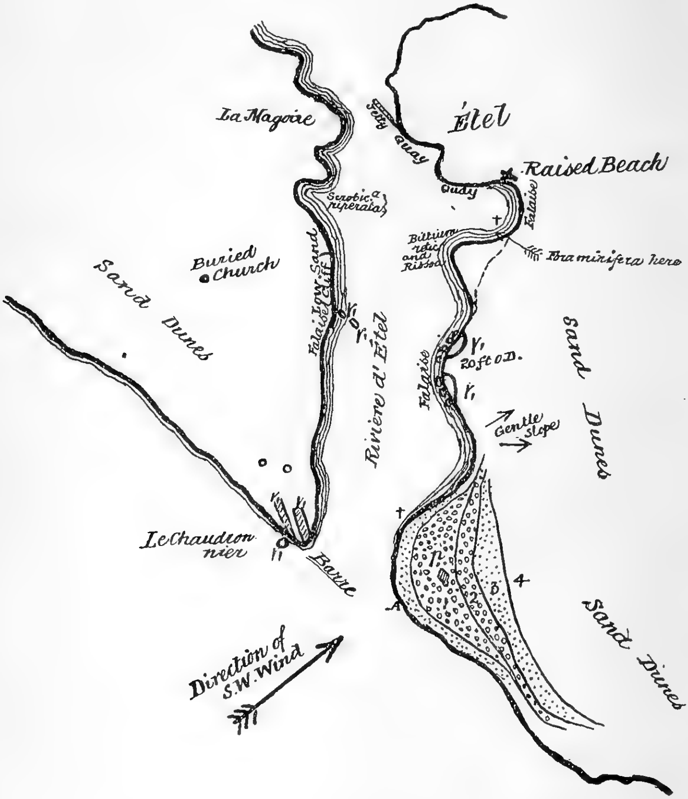


FIG. 3. Diagram of the Rivière d'Étel below Étel and La Magoire.
1, 2, 3, 4, successive terraces. *p*, pond. Y_1, granulite outcrops. † †, marine mollusca. A, steep face of present beach.
Sepia officinalis, *Bittium reticulatum*, *M. edulis* (Young), *Cy. europæa*, *Cardium edule*, various Tapes, *Donax vittatus*: very abundant on left bank from † to †.

The sea-front material, now acted on by the waves, consists of a coarse sea-sand which appears to be driven in from seaward. The small pea-gravel appears to be much older than this coarse sea-sand, and the question naturally arises whether the former is not rather to be correlated with the before-mentioned Raised Beach (×), close to the town of Étel, especially as it stands at nearly the same level above

[1] Prestwich, Q.J.G.S., vol. xlviii, p. 282.

high-water mark. At any rate, one thing seems certain, viz., that the pea-sized gravel is not being added to by wind or wave at the present time, nor for a long time past. At the same time it is well to mention that the pebbles of the Raised Beach (×) stand directly on the bare granulite and are not underlain by the pea-gravel, though this may only be because so much of the foreshore of the Raised Beach has been destroyed by erosion.

§ 7. The pea-gravel and blown-sand rise in terraces, commencing above the coarse sand of the sea-front, in the various stages of consolidation which are roughly indicated by the accompanying section (Diagram, Text-fig. 4).

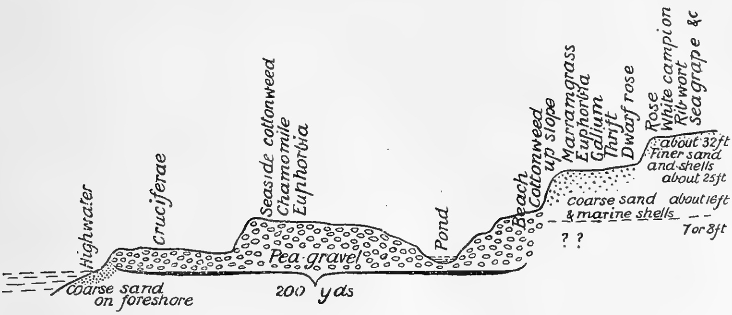


Fig. 4. Diagram of terraces at mouth of river, left bank. (For relative positions see Diagram, Text-fig. 3, p. 10.)

The plant which bears the brunt of the storm nearest the sea-front on the first terrace about 7 or 8 feet above high-water mark, is a Crucifer, *Cakile maritima*, Scopoli. I counted thirty-seven clumps of this hardy plant. The next terrace, about 9 feet higher, is occupied by seaside cotton weed, *Diotis maritima*, Coss.; chamomile, *Matricaria inodora*, var. *maritima*, L.; sea-spurge, *Euphorbia paralias*, L.; a smaller species of spurge, E. *peplis*, L. They occurred in the order named as to precedence, though they were, of course, mixed together in the rear.

Behind these there occurs a small depression, at a much lower level, containing brackish water, probably at sea-level, and about 150 yards from the sea-margin. The salt water would be able to filter in through the intervening sand and the depression would also act as a soak for fresh water from the dunes. The shells that occurred in the saline pond were *Natica catena* and *Cardium tuberculatum* principally.

Behind the second terrace and up its slope seaside cotton weed was in great abundance, the marram grass, *Ammophila arenaria*, Link,[1] only commencing to appear on this third terrace, at a height of 25 feet or so above high-water mark. With the marram grass were associated the above-named spurges, and also bedstraw, *Galium arenarium*, Loisel; *Ranunculus ficaria*, L. (lesser celandine); thrift, *Armeria maritima*, Willdenow; and a dwarf rose, from 1 to 4 inches high, *Rosa pimpinellifolia*, Loisel.

[1] Coste, *Flore de la France*, iii, p. 562.

Farther inland comes a fourth terrace, about 50 yards north, on which occur large patches of *Rosa pimpinellifolia*, and also equally vigorous sea-grape, *Ephedra distachya*, L., whose sweet, slightly acidulated berries in rank abundance coloured the dunes a brilliant coral-red. Also in smaller quantity occurred sea campion, *Silene maritima*, Withering; a dwarf ribwort, *Plantago maritima*, L.; and, of course, marram grass. What strikes one is the fact that the marram grass only occurs where the sand grains become small and therefore plays a subordinate part in 'dune formation' on this coast. Indeed, the mosses and lichens seem of almost equal importance with the marram grass in covering and consolidating the finer sand. This remark also applies to the sand-dunes of Perranzabuloe and the Trevose peninsula. Along this terrace at the foot there is a well-defined beach of large quartz pebbles.

On the opposite side, the right bank, of the Rivière d'Étel, near the lighthouse, where the sand is fine-grained, marram grass comes well forward to the advance-guard of yellow-horned poppy, *Glaucium flavum*, Crantz (*luteum*, L.), not more than 30 yards from the sea-front; the latter plant also occurs in abundance with sea-holly, *Eryngium maritimum*, L., on the second terrace of the left bank above described, where the plants are rather more sheltered (see Diagram 3).

Many other plants also occur in the groups on the third and fourth terraces; it is not, however, the purpose of this article to be botanically exhaustive, but only to trace the principal plant-agents in helping to consolidate the sand-dunes. Those who wish to do so, will find the subject more fully treated in a paper by M. Eugène Simon.[1]

§ 8. On the sand-dunes occur a number of marine shells, many of them of considerable size and weight, e.g. *Nassa reticulata* and *Purpura lapillus*. They are found at heights of quite 30 feet above the highest tides. It is difficult to account for their occurrence. They are not used for human food; these dunes are singularly void of bird-life; the dunes are not cultivated by man, nor, so far as one can see, have the shells been accidentally dropped in the places where they are found by farmers wheeling them across the dunes with seaweed, and they occur in places where fishermen's nets are not dried. Also they occur in places where there is no reason to carry them, for there are easier ways to the cultivated fields at the back of the sand-dunes. Nor, on the other hand, does wind seem to be the direct transporting agent. In the violent storm of October 8 last I placed single valves of such large shells as *Cardium tuberculatum* on their convex side; the south-west gale simply turned them over and propelled them no farther. Yet *C. tuberculatum*, either as whole shells or fragments, occurs plentifully at all levels up to the heights named above.

Probably the wind acts, in a sense, indirectly in moving molluscan and other remains up the sand-slopes to the higher levels. The movement of the sand-grains inland is facilitated by the threshing action of stranded and moored seaweed, which, detaching the particles from the beach, causes them to be borne along in the direction of the

[1] "Notes sur les associations végétales maritimes": Niort. Bull. Soc. Bot. des deux Sèvres, 1902 (1903), xiv, pp. 242–50.

wind. Quite large bundles of seaweed were observed rolling along the surface of the sand, and probably here we have an explanation of the fertility of the dunes in their own peculiar flora, and also of the presence of even large sea-shells on them, which shells, entangled in the masses of dryish seaweed would be easily transported inland and rolled upward. This would be especially easy on the sand-dunes of the left bank, between the falaises (or sea cliffs, granulite capped with sand) and the pea-gravel beach, since the slope here down to the Rivière d'Etel is a very gentle one, for it does not rise in the bluff terraces that characterize the sea-front.

§ 9. The materials that are triturated on the seashore or by the moving sand to yield the calcic portion of the sand-dunes are derived from marine Mammalia, Pisces, Mollusca, Echinodermata, Crustacea, and other flotsam and jetsam stranded on the shore. In October last two skulls of freshly dead *Delphinus delphis*,[1] and a complete *Phocæna communis*,[1] whole fishes of the genus tunny, the 'germon' *Thynnus alalonga*, were there in August last, and their bones in abundance in October. Crabs of the genus *Portunus* were also in evidence, and of echinoderms *Strongylocentrotus lividus* and an embryonic heart-urchin were not uncommon.

Mr. R. Holland has kindly examined the sea-sand submitted to him for foraminifera, and reports as follows: "A prolonged search has resulted in the discovery of a few miliolinæ only (probably *M. seminulum*, Linné). They are very poor specimens, and I have not come across a trace of any other genus of foraminifera. Besides the numerous molluscan shells I have noticed a few worm-tubes, one or two ostracod valves, a few echinoderm spines, and some very doubtful fragments of bryozoa."

The marine molluscan fauna of Étel resembles that of Weymouth in most respects. I give a list of species that I was able to collect. Those most abundant belonged to the Sepiidæ, Cardiidæ, Donacidæ, Mactridæ, Cypræidæ, Cerithiidæ, Veneridæ, and Mytilidæ. *Ostrea edulis*, *Pecten maximus*, and *Venus verrucosa* were almost entirely represented by old valves, much bored by *Cliona perforans*, such material being easily broken by the pounding action of the waves. These old shells are brought in from seaward. This is an important point when we consider the sand-dunes as encroaching on the sea, since the sea is adding to the land from its own resources.

CEPHALOPODA.

Sepia officinalis, L.
S. rupellaria, D'Orb.

GASTEROPODA.

Patella vulgata, L.
Helcion pellucidum (L.).
Fissurella reticulata, Don.
Calliostoma zizyphinus, L.
C. exasperata, Penn.
Gibbula umbilicata, Mont.
G. tumida, Mont.
G. cineraria, L.
Phasianella pullus (L.).
Scala communis, Lam.
S. clathratula (Adams).
Natica catena (Da C.).
N. alderi, Forbes.
Littorina littorea (L.).
L. littoralis, L.
L. rudis, Maton.
Rissoa costata, Adams.
R. costulata, Alder.
R. parva, Da C.

[1] Perhaps these should be excluded as they were probably killed by fishermen, but they show the possibility of such material floating ashore.

Rissoa violacea, Desm.
R. striata, Adams.
R. membranacea, var. *rabiosa*, Mont.
R. proxima, Alder.
R. rufilabris, Mont.
Alvania lactea, Mich.
Barleeia rubra, Mont.
Bittium reticulatum (Da C.).
Turritella communis, Risso.
Chenopus pes-pelicani, L.
Cypræa europæa, Mont.
Ocinebra erinacea (L.).
Purpura lapillus (L.).
Nassa reticulata (L.).
N. incrassata (Strom.).
N. pygmæa, Lam.
Buccinum undatum, L.
Bela turricula, Mont.
Mangilia (*Hadropleura*) *septangularis*, Mont.
M. costata (Don.).
Thesbia nana (Lovén).
Actæon tornatilis, L.
Dentalium dentalis, L.
Acera bullata, Müll.

PELECYPODA.

Anomia ephippium, L.
Arca lactea, L.
Mytilus edulis, L.
M. adriatica, Lam.
Ostrea edulis, L.
Pecten maximus, L.
P. varius, L.
P. pusio, L.
P. opercularis, L.
Lima hians, Gmel.
Diplodonta rotundata, Mont.
Tellina incarnata, L.
T. balthica, L.
T. tenuis, Da C.
T. donacina, L.
Gastrana fragilis (L.).
Donax vittatus (Da C.).
Spisula solida, var. *elliptica*, Brown.
Mactra stultorum, L.
Venus fasciata (Da C.).
V. verrucosa, L.
V. gallina, L.
V. chione, L.
Irus irus, L.
Tapes decussata, L.
T. aureus, Gmel.
T. pullastra, L.
T. virgineus, L.
Cardium tuberculatum, L.
C. norvegicum, Speng.
C. edule, L.
Psammobia vespertina, Ch.
P. ferroensis, Ch.
Solen siliqua, L.
S. ensis, L.
Pholas candida, L.
Pandora inæquivalvis, L.

Brackish-water shells, brought down from the upper reaches, or living near Étel, where fresh water runs into the river, and mud accumulates.

Lutraria oblonga, Ch.
Scrobicularia piperata (Gmel.).

Helicella barbara (L.), so common on our own sand-dunes in Cornwall, Portland, etc., was not observed at Étel. It occurred, with other xerophilous molluscs, at Auray, sunning itself on the hottest day of August last in the hottest places in bright sunshine on walls. On the other hand, *Helix pisana*, Mull., in countless myriads, provides its quota of material, organic and inorganic, to the general mass of the dunes. It is accompanied by *Pomatias elegans*, Mull., and *Helicella itala*, L., in considerable numbers.

§ 10. The rough proportion of calcic material in the sand of the dunes is about one part in three by weight. I carefully dried the sand from the dunes, and then treated it with hydrochloric acid; it was afterwards carefully washed eight times to remove the acid, and the residue after being thoroughly dried was again weighed, with the above result. Out of 875 gr. (2 oz.) Avoir., so treated, the residual quartz, mica, etc., weighed 582·625 gr., showing a loss by dissolution of 292·375 gr. of calcic material. *Bittium reticulatum* is so abundant as in places to colour the dune sand brown. The colouring matter was dissolved with the shell material.

§ 11. Much work remains to be done at our own sand-dunes, as

1

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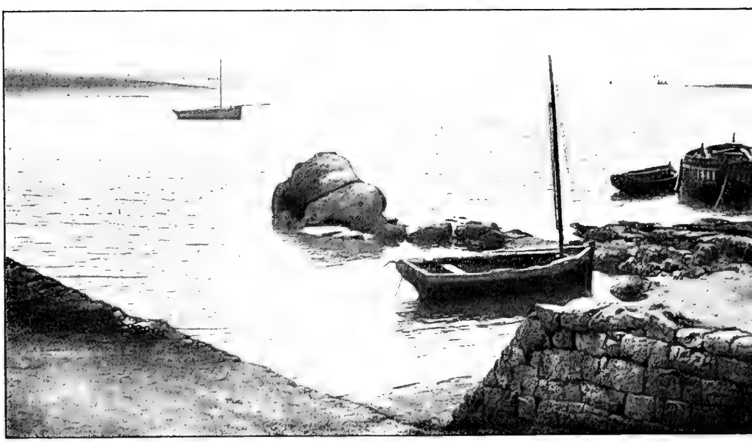


3

Fig. 1. Submerged Dolmen near Carnac Plage.
,, 2. Granulite rocks at Cap de Garde.
,, 3. View southwards close to the Raised Beach, Étel.

witness the hitherto unsuspected occurrence, November, 1908, of an old lake-bottom at Perranzabuloe,[1] 200 feet O.D. Though much of this chara-marl has been carted away by agriculturists as fertilizing agent, enough remains to yield a most curious limnic molluscan fauna, scarcely to be paralleled according to Mr. A. Santer Kennard, F.G.S., among the existing British freshwater fauna of the present day.

I have to thank Mr. W. H. Griffin and my wife for botanical help; and my friend Dr. Henry Woodward, F.R.S., for this opportunity of placing my notes for revision, if needed, before abler and more competent minds who have given thought to this fascinating subject.

EXPLANATION OF PLATE IV.

FIG. 1. Dolmen-sous-marin near Carnac Plage.
,, 2. Granulite rocks at Cap de Garde. The Chaudronnier, or Pierre d'Étel, surmounted by a beacon. The Lighthouse stands somewhat inland (see next view).
,, 3. Étel, view southwards from close to the Raised Beach. The Lighthouse and storm signal station are to the right of the Chaudronnier.

IV.—Pleochroic Halos.

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

(PLATE V.)

THE subject of 'pleochroic halos' has become endowed with peculiar interest since Professor Joly suggested that they are due to the radio-activity of the inclusions round which they occur.[2] On looking into such petrographical literature as I possess, it appears that very few precise observations have been made regarding these halos, and it has occurred to me, therefore, that some of my own notes on the subject may be of general interest.

Minerals causing or showing Halos.—The usual type of halo, as seen in rock sections, is a dark spot of roughly circular outline surrounding a small centrally situated enclosure in another mineral. The enclosing mineral may or may not itself be pleochroic, though it usually is so, or would appear so in thicker slices. The following is a list of minerals which have, to the writer's knowledge, been found to show halos, though it must be stated that in some of them the phenomenon is very rare: biotite, augite, hornblende, muscovite, chlorite, tourmaline, cordierite, staurolite, and andalusite. As to the minerals producing the halos, identification is not always easy, owing to their minute size. The following have come under the writer's notice: zircon, sphene, apatite, orthite (allanite), and epidote. It is needless to point out that all these latter minerals (except, perhaps, epidote) are known to be, comparatively speaking, strongly radio-active. As far as the rocks are concerned, halos are far more common in those of igneous origin than in the other classes, and are especially noticeable in the plutonic types, particularly the granites. It may be noted that even zircon, round which halos are most frequently met with, may occur enclosed in such a susceptible mineral as biotite without the slightest trace of

[1] Proc. Malac. Soc., vol. viii, pp. 247 and 374.
[2] Phil. Mag., 1907, p. 381.

any halo being seen. However, a halo round zircon is certainly the normal state of affairs, and the same may be said of orthite. It is curious to notice that large crystals of these minerals may fail to give rise to halos, though these last may be conspicuous round the smaller crystals in the same slice. Round apatite and epidote halos are only occasionally seen, and are usually faint, while round sphene they are extremely rare.

Shape of Halos.—It is evident that, if three dimensions are considered, halos are usually spherical, and thus give circular sections, except in cases where the enclosed crystal is distinctly elongated and of sufficient size for the difference of length and breadth to be appreciable. In the case of large irregular grains or granular aggregates the halo may be quite irregular in shape, but extends to a uniform distance from each part of the margin of the substance which it surrounds.

Size. — A feature revealed by measurement is the remarkable uniformity in size of the halos. The distance to which they extend from the edge of the enclosed crystal appears practically uniform in nearly all cases. Of course there are numerous instances where halos apparently smaller than usual are observed, owing to the dark sphere not having been cut centrally, but in these no nucleus can be seen. There do, however, appear to be some small halos which cannot be thus accounted for. On the other hand the alteration of minerals like orthite tends to produce stains which spread principally along cracks or cleavage planes, and must be carefully distinguished from real halos.

The following are some approximate measurements, made by means of an eyepiece micrometer, of the breadths of fairly well-marked halos seen round various distinctly visible minerals in a variety of rocks:—

Round Zircon.

	mm.
In biotite of granite, Haytor, Dartmoor	·03–·04
In biotite of granite, Rubislaw, Aberdeen	·03
In biotite of granite, Cowra, New South Wales	·035
In biotite of granite, Gadara, New South Wales	·02
In biotite of granite, Cape Town	·035
In biotite of granite, Matopos, Rhodesia	·03–·04
In biotite of granulite, Rhodes' Drift, Rhodesia	·04
In hornblende of granite, Weinheim, Baden [1]	·03
In hornblende of granite, Bulawayo, Rhodesia [1]	·03
In hornblende of diorite, Jahonda, Rhodesia	·035
In augite of granulite, Amazon Mine, Rhodesia [1]	·03
In chlorite of granite, Mountsorrel, Leicester	·03
In chlorite of granite, Matopos, Rhodesia	·03
In chlorite of granite, Cowra, New South Wales	·04
In tourmaline of granophyre, Cornwall	·03–·035
In tourmaline of granite, Cape Town	·03
In cordierite of granulite, Bodenmais, Bavaria	·045
In cordierite of granite, Cape Town	·035
In 'pinite' of granite, Cape Town	·035

Round Apatite.

In biotite of granite, Cape Town	·03
In biotite of diorite, Hillside, Rhodesia [1]	·03
In biotite of granulite, Amazon Mine, Rhodesia	·02
In biotite of granulite, Rhodes' Drift, Rhodesia	·03

[1] Nature of enclosed mineral somewhat doubtful.

Round Sphene.	mm.
In biotite of granulite, Amazon Mine, Rhodesia	·02
In hornblende of granite, Umguza River, Rhodesia	·03
In augite of syenite, Hillside, Rhodesia [1]	·03
Round Orthite (Allanite).	
In biotite of granite, Matopos, Rhodesia	·03–·04
In biotite of granite, Zimbabwe, Rhodesia	·035
In hornblende of granite, near Blanket Mine, Rhodesia	·03
In hornblende of 'tonalite', Adamello, Tyrol [1]	·035
In hornblende of diorite, Jahonda, Rhodesia	·04
Round Epidote.	
In chlorite of granite, Matopos, Rhodesia	·03
In biotite of granite, Gadara, New South Wales	·025

The above measurements are necessarily somewhat rough, as it is difficult to keep an eye on the halo and the micrometer scale at the same time. However, the general result is to emphasize the uniformity of size and the fact that there does not seem to be any definite relation between such variations as are noticed and the minerals concerned.

Halos and Radio-activity.—Professor Joly has pointed out that the penetration of the α rays emitted by radium compounds is about ·04 mm. in the case of aluminium, and having regard to the slightly greater density of the minerals examined, the results are in close agreement with the theory that the halos are due to the alteration of the surrounding minerals by those rays.[2] Some of the smaller halos were indistinct, and it seems possible that in several cases where rather low values were obtained, the radio-active substance was present merely as an inclusion in the interior of the mineral to which the halo appeared due. This is the more probable as such minerals as apatite and sphene cannot be radio-active in virtue of their normal constituents, or even their usual impurities.[3] Epidote, too, may owe its occasional activity to minute inclusions of orthite. As bearing on this point, may be noted a granite from the Zimbabwe Ruins in Rhodesia, which contains apparently primary epidote enclosed in biotite. The epidote in turn encloses irregular patches of orthite, and wherever the latter approaches within ·035 mm. of the edge of the epidote, the biotite within that limit shows the usual darkening. It is noteworthy that zircon may always be expected to contain traces of thorium, and orthite invariably contains that element in appreciable amounts, and probably uranium as well in some cases. From a petrological point of view it seems as if thorium should be a far more potent cause of radio-activity in the earth's crust than uranium and radium. We know of no widely distributed uranium-bearing rock-former, while zircon is found everywhere, and orthite is far from rare in many regions.[4] Over 15 per cent. of my slides of granites contain it. Monazite, always rich in thorium, is also

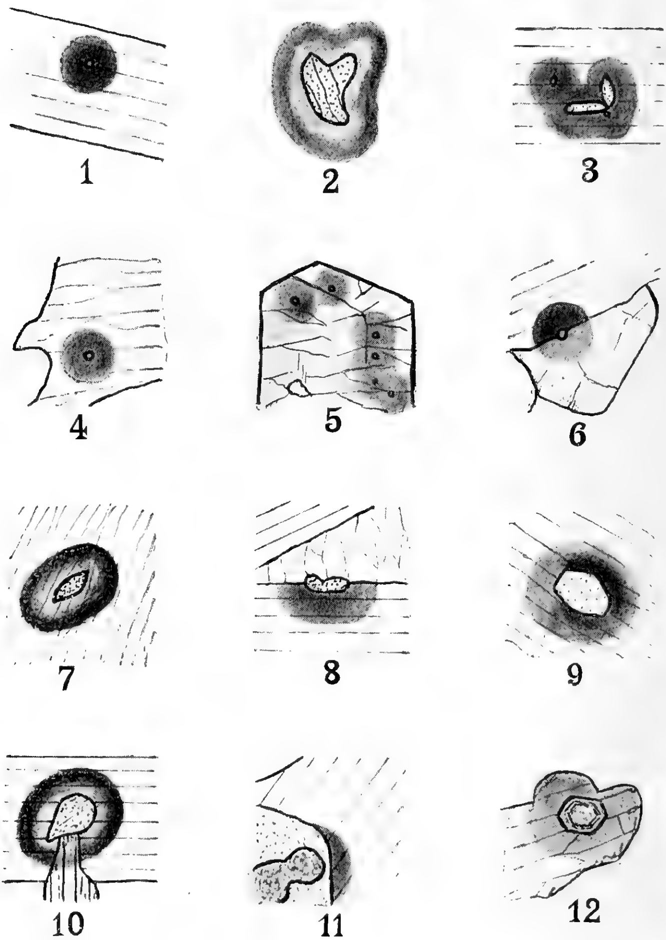
[1] Nature of enclosed mineral somewhat doubtful.
[2] *Radio-activity and Geology*, p. 68.
[3] See, however, Strutt, Proc. Roy. Soc. A., 1908, p. 275.
[4] See, for instance, Geol. Mag., 1903, Dec. IV, Vol. X, p. 347, and *Geology of South Rhodesia*, pp. 29–32.

found in many rocks. It is as yet scarcely possible to judge how the recently discovered radio-activity of potassium affects the question, though the abundance of that element renders the fact of obvious importance.

Various Features.—When the halos are fairly intense, they usually have quite well-defined boundaries, much more so than one is inclined to think before making a series of observations on the point. Where they are clearly perceptible in the direction of minimum absorption they show no increase of diameter when placed in the position of maximum absorption. Sometimes, however, a halo appears in the latter position, whereas none was perceptible in the direction at right angles to it. This is especially the case with such faint halos as those sometimes seen round epidote or sphene, or those in cordierite. The more intense halos are usually uniform in tint from inside to outside, or slightly lighter towards the outer edge. Irregularities in distribution are, however, fairly frequent, and the halos are sometimes dark and light in uneven patches. In certain cases, too—always, apparently, round rather large inclusions—the halos may have a rim darker than the interior. Thus, in the granite to the north of Kahlele's Kraal, in the Matopo Hills, Rhodesia, there are well-marked halos round good-sized orthite crystals enclosed in biotite. These halos are usually very sharply defined on the outside, and have the margins distinctly darker than the parts nearer the orthite. A similar feature may be noticed round some of the zircons in a biotite granulite from the neighbourhood of Rhodes' Drift on the Limpopo River, Rhodesia. It is also well seen round the larger zircons in the well-known cordierite granulite of the Bodenmais, Bavaria.

The halos round the minute zircons in the tourmaline of the Cornish granophyre (quartz-porphyry) in the list given above are interesting as extremely good examples of a phenomenon distinctly rare in tourmaline, though noticed long ago by Michel Lévy.[1] That this mineral does not readily lend itself to the formation of pleochroic halos is obvious from the evidence of such rocks as the Cape Town granite. My slides of specimens from near the contact show several instances of small zircons at the junction of biotite flakes and tourmaline crystals, and whereas the biotite shows a semicircle of intense pleochroism, the halos are incomplete, owing to the tourmaline being entirely unaffected. The same fact was noted at several junctions of biotite and cordierite, though in one case a good example of a composite halo, half in biotite and half in cordierite, was observed. Several fairly distinct halos were also seen round zircons, entirely enclosed in tourmaline, and we may perhaps infer that in these particular cases the enclosures were more strongly radio-active than usual. It is noticeable that where the cordierite of this rock has been altered into the so-called 'pinite' pseudomorphs, the halos are much more intense than in the fresh cordierite itself. Halos in hornblende are rather rare, though this is perhaps due partly to the much greater scarcity of inclusions than in biotite,

[1] See *Minéraux des Roches*, p. 288.



Pleochroic Halos around inclusions in various minerals.

which seems always to have crystallized by preference on a nucleus of previously formed accessory minerals. In contrast to tourmaline and hornblende, it is remarkable to find halos well shown in such minerals as augite and muscovite, which are not normally pleochroic. It is also an interesting point that halos never seem to occur in minerals capable of causing them, a fact which appears entirely in accord with the radio-active theory of their origin. Thus there are none round the inclusions of zircon in the large orthite crystals of the Jibuyi River granite in North-Western Rhodesia, nor does the epidote of the same rock show any where it encloses orthite crystals, a feature which may also be noticed in numerous other Rhodesian granites, e.g. those of the Matopos, Kalomo, and the Zimbabwe Ruins.

I must mention, in conclusion, my obligations to Mr. G. W. Card, of Sydney, who sent me the New South Wales rocks mentioned above, and to Mr. A. E. V. Zealley, who kindly brought to my notice the Cornish granophyre, also referred to.

EXPLANATION OF PLATE V.

Fig.

1. Ordinary type of circular halo round zircon in biotite, breadth about ·035 mm. In granite of Matopo Hills, Rhodesia.
2. Halo round irregular zircon inclusion in cordierite, rim of halo darker than interior. In granulite of Bodenmais, Bavaria.
3. Halos round group of zircon crystals in biotite. In granite of Sea Point, Capetown.
4. Halo round zircon in hornblende, breadth about ·035 mm. In quartz diorite of Jahonda, Rhodesia.
5. Halos round zircon in tourmaline. In Cornish granophyre, exact locality unknown; slide lent by A. E. V. Zealley, A.R.C.S.
6. Halo partly in biotite and partly in cordierite, round zircon. In granite (near contact) of Sea Point, Cape Town.
7. Halo, with dark rim, round zircon in biotite. In biotite granulite, near Rhodes' Drift, Limpopo River, Rhodesia.
8. Semicircular halo in biotite, not extending into adjacent tourmaline. In granite, Sea Point, Cape Town.
9. Halo, unevenly tinted, round apatite in biotite. In granulite, near Rhodes' Drift, Rhodesia.
10. Halo, with dark rim, round orthite (allanite) in biotite. In granite, north of Kahlele's Kraal, Matopo Hills, Rhodesia.
11. Halo in biotite, near inclusion of orthite in epidote. In granite, near Zimbabwe Ruins, Rhodesia.
12. Halo, about ·04 mm. in breadth, round orthite in hornblende. In quartz diorite of Jahonda, Rhodesia.

(The magnification is about 100 diameters.)

V.—The Ore-bearing Pegmatites of Carrock Fell, and the Genetic Significance of Tungsten-ores.

By A. M. Finlayson, M.Sc., Assoc. Otago School of Mines, F.G.S., Assoc.Inst.M.M.

Introduction.—The wolfram veins in the Grainsgill greisen, near Carrock Fell, are an example of ore-bearing pegmatites, a vein-type uncommon in the British Isles, and one, moreover, the study of which is of much interest in its relation to ore-genesis. The veins have long been known, and intermittently exploited for tungsten-ore, but their economic prospects are not bright. Of previous workers, Mr. Alfred

Harker has described the greisen which carries the veins,[1] while the various mineral occurrences have been recorded by Mr. J. G. Goodchild[2] and others.

The Country Rock.—The veins occur in Brandy Gill, a small stream running into the Caldew from the western slopes of Carrock Fell. The country rock is a detached intrusion of greisen, related to the Skiddaw granite, and of post-Silurian age. Mr. Harker has pointed out that it is an acid modification of this granite, containing 77·26 per cent. of silica, as against 75·223 per cent. in the normal biotite granite of Skiddaw.[3] In the ore-bearing portion, felspar becomes very subordinate or disappears altogether, white mica replaces biotite, and quartz phenocrysts compose the bulk of the rock. Tourmaline occurs occasionally, but topaz and cassiterite are absent. In classing this rock as a greisen, Mr. Harker has shown that its features are due, not in this case to the action of pneumatolytic processes on a normal granite, but to intense mechanical pressure on the magma, resulting from the post-Silurian crust-movements, at the time of its intrusion.[4]

The Grainsgill greisen has many features in common with the *beresite* of the Urals, which contains the gold - quartz veins of Berezovsk,[5] and with the *alaskite* of Mr. J. E. Spurr.[6] The latter rock, an acid modification of normal granitic or syenitic intrusions, occurs as dykes at Goldfield [Nevada], in the Yukon gold-belt of Alaska, and elsewhere. These various types are probably closely allied in nature and origin.

The Veins.—The wolfram veins in the greisen consist of some half-dozen chief members running north and south across Brandy Gill, and outcropping on the steep slopes on either side of the valley. They vary in width from a few inches to 3 or more feet, and consist essentially of coarse quartz, with flakes of pale mica and crystals of pale or bluish-green apatite. The vein-walls, though fairly well-defined, are not marked by clay selvages or slickensides, the veins being, in the phraseology of the American miner, "frozen to the country." Another notable feature is the marked absence of pneumatolytic effects, such as the development of schorl-rock, topaz, or fluorspar in the vein-zones.

The most easterly vein, which is also the largest, carries wolframite, with a subordinate quantity of associated scheelite, distributed in irregular bunches through the vein. The quartz is conspicuously banded and comby, and small vughs are common. Some arsenopyrite is generally present, scattered through the veins in small crystals. Molybdenite also occurs, in its usual habit, but this mineral appears to be chiefly developed in a single vein towards the west, which is

[1] Quart. Journ. Geol. Soc., 1895, vol. li, pp. 139 et seqq.

[2] "Contributions towards a list of the minerals in Cumberland and Westmorland": Trans. Cumb. and West. Assoc., 1881–2, vii, p. 101; 1882–3, viii, p. 189; 1883–4, ix, p. 175.

[3] Harker, loc. cit. sup.

[4] Id. ib., p. 143.

[5] Von Arzruni, *Zeits. deutsch. geol. Gesell.*, 1885, xxxvii, p. 873, and Posepny, *Guide du VII Congrès Géol. Internat.*, 1897, v, p. 42.

[6] "Geology of the Yukon Gold Belt, Alaska": 18th Ann. Rep. U.S. Geol. Surv., 1896–7, pt. iii, p. 230.

practically free from tungsten-ores. The small size of the veins and the sparing quantity and irregular distribution of the ores give no promise of ore-bodies of any consequence. As secondary products, there appear small quantities of the yellow tungstite (tungstic ochre) and molybdite (molybdic ochre). Native bismuth and bismuthinite are also recorded from this district, as well as the mineral grünlingite, a variety of tetradymite having the formula $Bi_4 S_3 Te$.[1]

The Vein-minerals and their Relations.—The quartz of the veins is glassy and crystalline, in coarse granules, and containing scattered patches of white mica. The apatite occurs in long striated prisms, terminated by the base or pyramids, and its colour varies from pale yellow or lemon-yellow to green. An analysis of the mineral gave the following result, showing it to be a fluor-apatite :—

CaO	= 54·11	Al_2O_3	= 0·87
P_2O_5	= 40·56	Fe_2O_3	= 1·05
F	= 2·98	MgO	= 0·24
C	= 0·66		
		Total	100·47

The vein-mica is commonly gilbertite, of a yellow or greenish tinge, frequently associated in flakes with the apatite. In Cornwall, where it was first described, this species often occurs as an alteration-product of orthoclase,[2] and in some districts it is pseudomorphous after both scheelite and apatite. Here, however, it appears to be of primary origin. An analysis of the mineral revealed the presence of 0·92 per cent. of fluorine. This is of interest, in view of the widespread occurrence of fluorine in potash-micas, which has lately been emphasized by Mr. J. E. Spurr.[3] Thus the gilbertite from Ehrenfriedersdorf contains up to 1·04 per cent. of fluorine.[4] The very small quantity of fluorine or other 'mineralizers' in the Cumberland veins is in harmony with the absence of pneumatolytic products.

The wolframite occurs in coarse bunches embedded in quartz. The prism-faces are longitudinally striated, and fairly complete crystals are not uncommon, the usual form being a combination of prisms and ortho-pinacoid, terminated by ortho-domes and pyramids. The composition of the mineral, as determined by analysis, is as follows :—

WO_3	= 76·24
FeO	= 16·39
MnO	= 6·05
CaO	= 1·05
MgO	= 0·11
Total	99·84

The scheelite is white to brownish-yellow in colour, and occurs, when crystallized, in tetragonal bi-pyramids. Under the microscope it is colourless, and when suitably cut shows its prismatic cleavages, *p* (111) and *e* (101), intersecting. The individual crystals, as distinguished under crossed nicols, are coarse and closely interlocked.

[1] Muthmann & Schroeder, *Zeits. Kryst. u. Min.*, 1898, xxix, p. 144.
[2] F. H. Butler, *Min. Mag.*, vii, p. 79.
[3] "Geology and Mining Industry of Tonopah": Prof. Paper No. 42, U.S. Geol. Surv., 1905, pp. 231–3.
[4] Frenzel, *Jahrb. Min.*, 1873, p. 794.

The mineral has been analysed by Traube, with the following result[1]:—

WO_3	= 79·97
MoO_3	= 0·35
CaO	= 19·27
Total	99·59

The presence of molybdenum is worthy of note, this constituent having been shown by Traube to be almost universally present in scheelite.

The relations of the minerals may be more clearly studied under the microscope. The opaque wolframite encloses quartz in thin strings along its cleavage-planes, as well as in granular aggregates. Separated grains of quartz are often seen to extinguish simultaneously, and at other times the two minerals simulate a graphic intergrowth. Again, quartz may occur as a thin selvage to the wolfram. The intimate association of these two constituents clearly shows close relation in order of deposition. While frequently there has been practically simultaneous deposition, on the whole the wolframite appears to have preceded the quartz. Crystals of arsenopyrite are almost invariably deposited on wolfram or formed in microscopic cavities of the ore. This sulphide is probably very largely of metasomatic origin.

The scheelite, in contrast to the wolframite, is remarkably free both from arsenopyrite and from quartz. This would be expected from the fact that the arsenopyrite is a metasomatic product after wolframite, and the wolframite and quartz were deposited about the same time, while the scheelite is clearly of later date. This mineral frequently fills cracks in the wolframite, and while the border-line between the two minerals is generally sharp, the scheelite is invariably deposited or grown on the older mineral. Occasionally the line of junction is irregular, and shows a gradual progression of the scheelite by replacement of the wolframite. The observed relations leave little doubt that the scheelite is metasomatic, although the processes are not in every case obvious under the microscope. The order of deposition of the minerals was apparently (1) wolframite and quartz, (2) arsenopyrite and scheelite.

It is to be noted that there are two lime-bearing minerals in these veins, namely, scheelite and apatite. The latter was perhaps the earliest of all in order of deposition, and it is not clear to what extent, if at all, the scheelite has derived its base from this constituent. In any case, this occurrence of lime is of interest, since it has been pointed out that in the magmatic differentiation of the greisen from the biotite granite of Skiddaw there has been a reduction of the alkalis and alkaline earths by 50 per cent.[2] The lime in these two vein-minerals may then be taken to represent a portion of the surplus bases rejected by the greisen during its differentiation and crystallization, the lime being brought up at a later stage in the last phase of the magmatic processes, i.e. in the formation of the pegmatite-veins.

Tungsten-ores and Metasomatism.—The formation of tungsten-ores

[1] *Jahrb. Min.*, Beil. Bd., 1890, vii, p. 232.
[2] Harker, loc. cit. sup., p. 142.

is very frequently due to metasomatic replacement, and this may take place in one of two directions. There may be a replacement of the acid radicle by tungstic acid; or there may be a replacement of the base by lime, or by iron and manganese oxides. The former process has taken place, for example, in the scheelite deposits of Trumbull, Connecticut,[1] and in the scheelite-veins of Otago, New Zealand.[2] In both these cases, tungstic acid has combined by replacement with lime-bearing minerals in the vein-zone. Another important example is the wolfram-ore of the Black Hills, South Dakota.[3] The second process is observed where scheelite is metasomatic after wolframite, as in the present instance; and likewise where the reverse change has occurred. Thus, in the deposits at Trumbull, Connecticut, wolframite occurs pseudomorphous after scheelite. The latter change, i.e. from scheelite to wolframite, appears to be much the commoner.

Fissure-veins at Grainsgill.—There occur, associated with the Grainsgill pegmatites, typical lead-quartz veins in fissures. An example is to be seen within a few yards of the most westerly pegmatite-vein, and contained also in the greisen. It is bounded by sharply defined walls with clay selvages. The vein-filling is of brecciated, or banded and cavernous quartz, and the ore consists of small bunches of well-crystallized galena, with a little chalcopyrite. This vein has clearly been deposited in a fissure formed in the rock long subsequent to its consolidation, the fissure being, like all those which carry the lead-zinc and copper veins of the Lake District, of post-Carboniferous age. We have here, then, two distinct vein-types, which show a striking difference, both in origin and in age.

In this connexion, it is worthy of note that the lead-veins of the Lake District have yielded two minerals allied to those in the pegmatites, namely, wulfenite from Caldbeck Fell[4] and stolzite from Force Crag.[5] There has apparently been a reaction, at considerable depth, between the older tungsten and molybdenum ores and the younger lead-ores, which points to a broad genetic connexion between them.

Genetic Relations of the Grainsgill Pegmatites.—The modern views on the nature and origin of pegmatites have been recently summarized by J. B. Hastings,[6] who concludes that their essential feature is their dependence on aqueo-igneous intrusion, as applied to the influence of water in conjunction with heat in causing the liquidity of granitic magmas. In different cases it may be difficult to determine to what extent igneous intrusion on the one hand, and magmatic waters on the other, have been predominant, and it is impossible to postulate exclusively either aqueous or igneous agency, since there has clearly been a combination of both factors. G. H. Williams, in discussing the origin of the Maryland pegmatites,[7] concludes that they are of

[1] W. H. Hobbs, 22nd Ann. Rep. U.S. Geol. Surv., 1900–1, pt. ii, p. 13.
[2] A. M. Finlayson, "The Scheelite of Otago": Trans. N.Z. Inst., 1907, xl, p. 117.
[3] J. D. Irving, Trans. Amer. Inst. Min. Eng., 1902, xxxi, p. 683.
[4] J. G. Goodchild, Geol. Mag., N.S., 1875, Dec. V, Vol. II, p. 565.
[5] Greg & Lettsom, *Mineralogy of Great Britain*, London, 1858, p. 411.
[6] Bull. No. 21, Amer. Inst. Min. Eng., May, 1908, p. 319.
[7] 15th Ann. Rep. U.S. Geol. Surv., 1893–4, p. 678.

two types—segregation pegmatites and intrusive pegmatites. The view that pegmatites grade into normal quartz-veins has been maintained in different districts by various writers, as, for instance, Crosby & Fuller,[1] J. F. Kemp,[2] A. H. Brooks,[3] Joseph Barrell,[4] and A. C. Spencer.[5] R. Beck concludes that pegmatites are products of crystallization from superheated waters, which remained, after the separation of the chief constituents of the magma, as a concentrated solution containing the rarer metallic elements.[6] He is thus in agreement with Brögger, Arrhenius, Vogt, and Grubenmann, all of whom support the intimate relation between pegmatites and ore-veins. Hastings expresses similar views with respect to the pegmatites of the Eastern United States,[7] which he regards as true dykes, except where excess of water and of mineralizers have produced, first, pneumatolytic tin- and apatite-veins, and finally veins containing gold, silver, or galena.

The most pronounced advocate of the connexion between pegmatites and normal quartz-veins, however, is J. E. Spurr, who has advanced a theory of progressive derivation of gold-quartz veins from granitic magmas by siliceous magmatic differentiation.[8] While this hypothesis may be locally applicable, there are, in many districts, difficulties in the way of its acceptance, owing to the absence of transitions from one vein-type to another. To take a single instance known to the writer, the gold-quartz veins of the west coast of New Zealand,[9] while related to the tectonic movements and granitic intrusions of the Alpine region, show no relation whatever with the abundant pegmatites and barren quartz-veins of the granites themselves. Again, in the Grainsgill district under consideration we have, on the one hand, ore-bearing pegmatites representing the super-acid phase of segregation and differentiation of the magma; and, on the other hand, lead-quartz veins in fissures, showing no (structural) similarity to the pegmatites. They have clearly been deposited from circulating waters at a later date. The occurrence in the lead-veins, however, of the minerals stolzite and wulfenite, serves to link the two types together to a certain extent, and to indicate that the ores have probably been derived from a common source.

Geological Occurrence of Tungsten-ores.—The range of occurrence of tungsten-ores is very remarkable, and gives important evidence on the question of relations between the different vein-types. The facts of occurrence, with examples, are given below:—

1. *Pyrogenetic Minerals.*—Tungsten-ores occur as original pyrogenetic compounds in granitic and allied rocks, chiefly as small percentages of tungstic oxide, often with tin oxide and molybdic oxide, in tantalates

[1] *Technology Quarterly*, 1896, ix, p. 326.
[2] Bull. Geol. Soc. Amer., 1898, x, p. 361.
[3] 20th Ann. Rep. U.S. Geol. Surv., 1898–9, pt. vii, p. 425.
[4] 22nd Ann. Rep. U.S. Geol. Surv., 1900–1, p. 511.
[5] Prof. Paper No. 25, U.S. Geol. Surv., 1904, p. 41.
[6] Rep. Brit. Ass., Trans. of Sections, 1905, p. 400.
[7] Amer. Inst. Min. Eng., 1908, Bull. xxi, p. 319.
[8] Prof. Paper No. 55, U.S. Geol. Surv., 1905, p. 129, and *Economic Geology*, ii, No. 8, p. 781.
[9] A. M. Finlayson, Trans. N.Z. Inst., 1908, xli, p. 85.

and niobates. Scheelite is also recorded from granite at Chesterfield, Mass., with albite and tourmaline.[1] The scheelite occurring with piedmontite in a rhyolite at South Mountain, Penn.,[2] may also be pyrogenetic, while the segregations or secretions of wolframite in granite in the Whetstone Mountains, Cochise Co., Arizona, may be regarded as pyrogenetic.[3]

2. *Pegmatites.*—From these examples, it is a short step to the tungsten-bearing pegmatites, of which there are several types. In the first place, tungsten-ore occurs in pegmatites without tourmaline, as at Grainsgill, and similarly at Torrington, New South Wales, where it is associated with bismuth, monazite, fluorspar, and beryl.[4] Secondly, there is a wolfram-tourmaline-tin phase of pegmatites, as in the granite of the Southern Black Hills, where they carry wolframite, with cassiterite, columbite, tantalite, and tourmaline.[5] Likewise, at Etta Knob and Nigger Hill in South Dakota, the pegmatites carry wolframite and cassiterite with spodumene, lithia-mica, albite, and orthoclase.[6] A third type of pegmatites carries also iron and copper sulphides, as at Sadisdorf near Altenberg, where wolframite occurs with lithia-mica, fluorspar, apatite, and chalcopyrite,[7] and in the south part of the Sierra de Cordoba, Argentina, where the veins contain wolframite, apatite, mica, molybdenite, pyrite, and chalcopyrite.[8] Similarly, in granite near Encruzilhada, Rio Grande, Brazil, wolframite occurs in a quartz-vein with muscovite, pyrite, and chalcopyrite.[9] All these three types of pegmatite-veins are closely allied, and, further, they show clear transitions to the pneumatolytic type of vein, and to the normal type of sulphide-vein.

3. *Pneumatolytic Veins.*—In this well-known type the tungsten-ores are associated with tin and tourmaline, as in Cornwall. The type is also well developed in Tasmania and Northern New South Wales, while many of the Spanish and Portuguese occurrences are of this type, as at Villa Real and Castello Branco.

4. *Contact-deposits.* — In some instances, tungsten-ore occurs in deposits of contact origin, where it is generally associated with characteristic silicate-minerals of the contact zone, and where replacement has generally been a factor in its formation. Thus the scheelite deposit of Long Hill, Trumbull, Conn.,[10] appears to be of this type. The deposits lie in a zone between crystalline limestone and hornblende-gneiss, and are associated with epidote and zoisite. Again, scheelite occurs in the magnetite-sulphide deposits of Pitkäranta, Finland, where limestones have been intruded by granite.[11] In Tasmania, wolframite, cassiterite, bismuthinite, and molybdenite occur

[1] J. P. Iddings, *Igneous Rocks*, New York, 1909, vol. i, pp. 42, 68.
[2] G. H. Williams, Amer. Journ. Sci., 1896, xlvi, p. 50.
[3] F. L. Hess, Bull. 380, U.S. Geol. Surv., 1909, p. 164.
[4] *Mining Journal*, 1905, p. 170.
[5] F. L. Hess, Bull. 380, U.S. Geol. Surv., 1909, p. 131.
[6] W. P. Blake, Trans. Amer. Inst. Min. Eng., 1885, xiii, p. 691.
[7] R. Beck, *Zeits. für prakt. Geol.*, 1907, xv, p. 40.
[8] Bodenbender, loc. cit., 1894, p. 409.
[9] H. Kilburn Scott, Trans. Inst. Min. Eng., 1903, xxv, p. 510.
[10] W. H. Hobbs, 22nd Ann. Rep. U.S. Geol. Surv., 1900–1, pt. ii, p. 13.
[11] Otto Tröstedt, *Bulletin de la commission géologique de Finlande*, 1907, iv, No. 19.

in quartz-veins with fluorspar and wollastonite, in metamorphic Silurian limestone penetrated by quartz-porphyry.[1] These and other deposits where contact metamorphism has clearly been operative, are related to the other types here considered, and their mode of formation has been merely a local accident.

5. *Normal Fissure-veins.*—Tungsten-ores are abundant in quartz-veins and allied deposits with sulphides and gold-ores. In the first place, there are many occurrences which show mineralogical transitions from the tin-tourmaline type. Examples of these are the quartz-veins in granite at New Ross, Lunenburg, N.S., where scheelite and cassiterite occur with iron and copper sulphides;[2] and in the Moose River district, Halifax, N.S., where scheelite occurs in gold-quartz veins with arsenopyrite and some tourmaline. In the New England district of New South Wales, wolframite and scheelite occur in veins with cassiterite, bismuth-ores, and molybdenite in a greisen,[3] an occurrence which should perhaps be classed as pneumatolytic. The Cook and Cape Yorke district of Queensland shows a marked association of gold-tungsten-tin ores; and in the important Herberton and Hodgkinson districts of Queensland, the wolframite is associated with molybdenite and bismuth-ores. Near Maunda, east of Nagpur, in India, wolframite occurs in a gold district, in bedded quartz-veins in mica- and tourmaline-schists.[4] At the Panasquiera mines, in the province of Beira Baixa, Portugal, wolframite is found in quartz-veins with cassiterite, specularite, pyrite, arsenopyrite, and mica.[5] Near Tirpersdorf in the Saxon Voigtland, veins in the contact-zone of a granite boss carry wolframite with molybdenite and tourmaline.[6] In the Predazzo district of the Southern Tyrol, veins associated with the post-Triassic intrusions carry scheelite, with copper-ores, fluorspar, arsenopyrite, and tourmaline.[7] Many of these occurrences are more closely related to the pneumatolytic type, but they illustrate the impossibility, owing to the transitions, of drawing sharp dividing lines between one type and another.

Turning to more normal types, these are common all over the world, and comprise some of the most valuable tungsten deposits. The ore—wolframite, hübnerite, or scheelite—occurs in a quartz gangue, with the commoner sulphides, and nearly always some gold. In Spain, the deposits of La Sorpresa, in the province of Cordoba, consist of quartz-veins carrying wolframite and scheelite in granite and in the adjoining slate.[8] In the Cagliari district of Sardinia, scheelite occurs in quartz-veins with stibnite, a sulphide which is frequently associated with this ore.[9] The tungsten-ores of Canada

[1] W. H. Twelvetrees & G. A. Waller, Tasmanian Government Geological Reports, 1901, etc.

[2] E. R. Faribault, Sum. Reps. Geol. Surv. Canada, 1908, p. 169.

[3] Bull. Imp. Inst., London, 1909, vii, No. 2.

[4] L. Leigh Fermor, Recs. Geol. Surv. India, 1908, xxxvi, p. 301.

[5] *Mineral Industry* for 1906, xv, p. 747.

[6] R. Beck, *Zeits. für prakt. Geol.*, 1907, xv, p. 37.

[7] J. Block, *Sitzungsber. der Niederrheinischen Gesellsch. für Natur- und Heilkunde zu Bonn*, 1905, p. A, 68.

[8] *Mineral Industry* for 1906, xv, p. 747.

[9] Domenico Lovisato, *Atti della Reale Academia dei Lincei*, 1907, ser. v, xvi, Rendiconti, p. 632.

have been described by T. L. Walker.[1] The normal quartz-veins are well developed in Beauce Co., Quebec,[2] in various parts of the Nova Scotian gold-belt, and in the Cariboo and Kootenay districts of British Columbia.[3] In all these occurrences the tungsten-ore is found in quartz-veins with gold or in gold districts. In the northern Black Hills of South Dakota, wolframite occurs in a zone of refractory siliceous gold-ores, formed by replacement of crystalline dolomite.[4] At Lane's mine, Monroe, Conn., quartz-veins carry wolframite, often pseudomorphous after scheelite, together with native bismuth, pyrite, galena, etc. In the Snake Range, White Pine Co.,[5] and at Osceola,[6] both in the State of Nevada, hübnerite occurs with scheelite in quartz-veins in granite. In Boulder Co., Colorado, wolframite is abundant in quartz-veins in a district of auriferous sulphide and telluride ores.[7] In Arizona, wolfram-ores occur throughout the gold-belt.[8] Important occurrences are in the Whetstone Mountains[9] and the Dragoon Mountains,[10] Cochise Co. In the latter district the ore is chiefly hübnerite. At Julcani, in Peru, wolframite occurs in gold-quartz veins in diorite.[11] In Western Australia, scheelite is found at Ravensthorpe, in the Phillips River Goldfield, at Kalgoorlie, and in other gold districts. In New South Wales, scheelite is abundant in quartz-veins in and near the granite intrusions of the Cordilleran Goldfield, notably at Hillgrove, where the veins also carry scheelite.[12] In New Zealand, scheelite is common in the gold-quartz veins of the Otago goldfield,[13] while stibnite is another common ore in that region. The Otago district is one of Palæozoic slates and schists, devoid of igneous intrusions to which the ores might be related, but the gold-tungsten zone clearly belongs to the same province as the gold-belt of Eastern Australia. In concluding this survey of the occurrence of wolfram-ores, mention should be made of the common occurrence of stolzite as a subordinate mineral in lead-veins, and, similarly, of cupro-tungstite with other copper-ores.

Conclusions.—It has been seen how tungsten may be followed through all stages of ore-deposition from the original magma, without any breaks in the sequence. It appears first in pyrogenetic minerals, and passes then through the different phases of pegmatites, which represent the end-products of the differentiated magma, and contain concentrations of the rarer metallic oxides. It next appears in the pneumatolytic veins, the first of the after-effects of the intrusion, and passes progressively from these, where it is associated with tin and

[1] "Tungsten-ores of Canada": Dept. of Mines, Ottawa, 1909.
[2] A. R. C. Selwyn, Rep. Geol. Surv. Canada, 1893, v, p. 74 *AA*.
[3] T. L. Walker, loc. cit. sup., pp. 36 et seqq.
[4] J. D. Irving, Prof. Paper No. 26, U.S. Geol. Surv., 1904, p. 169.
[5] F. B. Weeks, Bull. 340, U.S. Geol. Surv., 1908, p. 263.
[6] Fred D. Smith, Eng. and Min. Journ., 1902, lxxvi, p. 304.
[7] Waldemar Lindgren, Ec. Geol., 1907, ii, p. 453.
[8] Forbes Rickard, Eng. and Min. Journ., 1904, lxxviii, p. 263.
[9] F. L. Hess, Bull. 380, U.S. Geol. Surv., 1909, p. 164.
[10] W. P. Blake, Trans. Amer. Inst. Min. Eng., 1899, xxviii, p. 543.
[11] E. A. V. de Habich, *Geol. Centralb.*, 1907, ix, i, p. 9 (Abstr.).
[12] E. F. Pittman, *Mineral Resources of N.S.W.*, Sydney, 1901, and Bull. Imp. Inst., 1909, vii, No. 2.
[13] A. M. Finlayson, Trans. N.Z. Inst., 1907, xl, p. 110; 1908, xli, p. 64.

tourmaline, to the various types of normal fissure-veins, where it is associated with sulphides of iron, copper, and antimony, and to a lesser extent with lead. Throughout the sulphide zones it constantly accompanies gold. This association of tungsten with gold is one of the most significant facts in the occurrence of tungsten-ores. Mention should here be made of the occurrence of strings of gold in alluvial wolframite in the Ballinvalley stream, co. Wicklow, Ireland,[1] but it is possible that the gold has here been deposited on the wolfram by secondary action in the auriferous alluvium.

It follows that tungsten, which is found in such a continuous series of vein-types, must give important evidence as to the ultimate source of the metals with which it is associated, and since tungsten is universally a product of the acid and superacid phases of magma-differentiation in the first place, it seems probable that it is to these magmatic phases that we must look for the ultimate point of departure of many gold- and sulphide-ores, just as in the case of tin-ores. While this line of evidence as to the source of gold-ores—especially when taken in conjunction with the authentic occurrences of primary free gold in granitic rocks—supports in part the hypothesis of Mr. J. E. Spurr,[2] it is clear that the genesis of gold-ores and sulphides is much too complex to be thus dealt with. While magmatic differentiation has probably been the fundamental factor at work, there are many gold-ores which have probably originated during an intermediate or basic phase of differentiation.

Apart from the view of derivation of ores by progressive magmatic differentiation, which is strongly supported by the evidence here discussed, there remains the problem of the origin of the vein-solutions. The view advocated by Mr. Spurr, that the quartz gangue of normal fissure-veins represents the extreme product of siliceous magmatic differentiation, seems to be of very limited application. The views as to the origin of vein-forming solutions are still somewhat conflicting, but it is doubtful if any theory of vein-formation can be comprehensive which demands the exclusive agency of ‘juvenile waters’, and which fails to recognize the work of underground solutions of meteoric origin in the middle and higher zones of ore-deposition.

The work in connexion with this paper was carried out at the Imperial College of Science and Technology, London, and the writer is indebted to Professor W. W. Watts for advice and criticism.

NOTICES OF MEMOIRS.

On the Evidences of a Former Land-bridge between Northern Europe and North America.[3] By R. F. Scharff, Ph.D., M.R.I.A.

THE author enunciated the theory some years ago that North-Western Europe and North-Eastern America had been connected with one another by land within comparatively recent geological times, and

[1] Bull. Imp. Inst., 1909, vii, No. 2, p. 171.
[2] Ec. Geol., ii, No. 8, p. 781.
[3] From the Proceedings of the Royal Irish Academy, 1909, vol. xxviii, Section B.

that the reindeer had probably utilized this land-connexion in gaining access to Europe from its supposed American centre of dispersion. Further studies have led to the conviction that a second and more southerly land-connexion, joining Scotland, Iceland, and Greenland with America, must have existed in later Tertiary times. This does not materially alter the general principle of his original views; and he still adheres to the belief in a North Atlantic land-bridge between Europe and America during the lifetime of the reindeer.

In 1897 Mr. W. S. Green gave us the results of his expedition to the Rockall Bank. Surrounded by deep water on all sides, this bank is of an average depth of 100 fathoms, and lies far out in the Atlantic to the west of Scotland. Dredging on the bank yielded only such shallow-water species of molluscs and other marine invertebrates as could not have lived there under the present conditions. Moreover, as all the specimens were dead, it was concluded that the bank had only subsided to its present depth within comparatively recent times.[1] In 1900 the Danish 'Ingolf' expedition to Iceland likewise reported having met littoral molluscs near the island at considerable depths where these animals could not possibly have lived. That such cases as these are due to accidental dispersal by floating icebergs containing shells in the ice-foot or by floating seaweeds, had been suggested; but the view that the occurrence of shore forms of animal life in deep water implies a depression of the land seems to meet with more general favour, especially as no icebergs are known to stray to the Rockall Bank at present.

More recently Professor Hull lays stress on the occurrence of channels in submerged platforms bordering the British Isles, and urges that they represent the drowned river-valleys and cañons of an ancient land-surface. By means of the Admiralty charts he succeeded in tracing the course of the River Shannon for a hundred miles beyond its present mouth, right to the edge of the continental platform, while he followed the continuation of the River Erne for a distance of 80 miles from the Irish coast.[2]

In America similar researches have been conducted, chiefly by Dr. Spencer,[3] but while Professor Hull advocates an elevation of the land during the early part of the Glacial period of 7000 to 8000 feet, Dr. Spencer suggests an uplift of 12,000 to 15,000 feet. A more cautious attitude on these oceanographic problems was adopted by Mr. Hudleston. He conceded that some sort of a bridge across the Atlantic may have existed during portions of the Tertiary era; but he did not believe in an uplift beyond 2000 or 3000 feet.[4]

The subject of continental shelves has lately received renewed attention from Dr. Nansen, and is discussed by him at great length. At several places, he argues, there is weighty evidence for the supposition that the drowned river-valleys have been sculptured after the

[1] W. S. Green, "Notes on Rockall Island": Trans. Roy. Irish Acad., 1897, xxxi.

[2] E. Hull, "Submerged Terraces and River Valleys": Trans. Vict. Inst., 1897, xxx.

[3] J. W. Spencer, "Submarine Valleys": Bull. Geol. Soc. America, 1903, xiv, p. 224.

[4] W. H. Hudleston, "Eastern Margin of North Atlantic Basin": Geol. Mag., 1899, p. 148.

formation of the continental shelves. The latter consequently have been dry land after their formation.[1]

The remarkable circumstance that the submarine fjord-valleys on the European and on the American side, and likewise the submarine ridges connecting the two continents, are situated at about the same depth makes it probable that the whole area had once been raised simultaneously, and had thus become connected by land. Dana long ago urged that the refrigeration of the climate at the close of the Tertiary era was connected with a period of high-latitude elevation,[2] and I cannot refrain from expressing my opinion, that the Glacial period was primarily due to the diversion of oceanic currents produced by changes in the distribution of land and water. With every respect for the views of those who hold different opinions, it seems to me that the peculiar phenomena connected with the Ice Age in Western Europe, and especially the apparent survival of southern species of plants and animals in Ireland through the Glacial period, are best explained by such a theory as that just stated.

It is especially the teachings of Edward Forbes and A. R. Wallace that led to the recognition of the significance of the present geographical distribution of animals and plants as an indicator of the changes which have taken place in the arrangement of land and water. They believed that many terrestrial animals and plants require a continuous land-surface for their dispersal. Yet the diversity and comparative richness of the fauna and flora of some of the oceanic islands, and the depth of water intervening between them and the mainland, had to be accounted for in some other manner. Neither Wallace nor Darwin was inclined to admit extensive geographical changes within the period of existing species. The distribution of plants and animals by 'accidental', or what Darwin called 'occasional', means of dispersal seemed to furnish them with a clue to the worldwide dissemination of certain species.

Darwin's experiments have found many imitators; and valuable observations tending to show that at any rate some of the more minute animals and plants are liable to be conveyed by occasional means of dispersal, have been made.

It would be idle to deny that the seeds of certain plants are carried to great distances by wind; that many others are undoubtedly transported by ocean currents; that some seeds are even scattered here and there by birds. My contention is, and I concur in this opinion with many eminent botanists, that only a small percentage of plants are disseminated and actually established in that manner. Most of them require for their dispersal a solid and continuous expanse of soil.

Sir Joseph Hooker evidently believed that the flora of Greenland had travelled across from Europe by a land-bridge in Pre-Glacial times. He considered the existing plants of the country as certainly older than the Glacial period; for he argued that the severity of the climate destroyed many species, while the remainder took refuge and survived in the southern parts of Greenland.[3] Professor James Geikie

[1] F. Nansen, *Norwegian North Polar Expedition*, 1904, iv, p. 192.

[2] J. D. Dana, *Manual of Geology*, 3rd ed., p. 540.

[3] J. D. Hooker, "Distribution of Arctic Plants": Trans. Linn. Soc., 1860, xxiii, pp. 252–5.

maintains that a land-connexion between Greenland, Iceland, the Faröes, and Scotland, must have existed, because the plants could only have migrated from Europe over a land surface,[1] but to him the idea of a survival of plants during the Ice Age in Greenland is inconceivable. He therefore argues that the land-bridge could only have existed in Post-Glacial times. Hence the Glacial period and its supposed adverse influence upon the flora of Northern Europe has now become the mainspring of most speculations as to the former presence or absence of a northern land-bridge.

The question of the supposed survival of plants through the Ice Age in Greenland largely depends on the problem whether or no the glaciers of that country had a vastly greater extension formerly than they have at present, and covered the whole of the land now free from ice. That the latter has never been entirely invaded by ice has been clearly demonstrated by the leader of the German Greenland Expedition, Dr. E. von Drygalski. The greater extension of ice in former times no doubt can be proved, he remarks; yet glaciers certainly never reached the cliffs and rock-pinnacles which abound on all parts of the coast-lands of Greenland.[2] No reason, therefore, can be adduced why the flora of Greenland should not have survived the Ice Age in that country, particularly as we have some grounds for the supposition that the land in the Arctic regions then stood higher than it does now.

It would be wrong to suppose that plant migration to the Faröes and Iceland has proceeded altogether from Europe. A stream has likewise advanced from the opposite direction. Thus in the Faröes we find at least seven plants unrepresented in the British Islands. These came from Greenland and Arctic America.

A small group of plants is of particular interest to Irish botanists, as being almost exclusively confined to the West of Ireland and North America. According to Messrs. Colgan & Scully,[3] the plants in Ireland which belong to this group include *Spiranthes Romanzoviana*, *Eriocaulon septangulare*, and *Naias flexilis*. All of these plants are indigenous and discontinuously distributed. An interval of more than 200 miles separates the northern and southern stations in Ireland of the rare orchid *S. Romanzoviana*. The water plants *E. septangulare* and *N. flexilis* inhabit not only some of the western Irish lakes, they occur also in Scotland.

Messrs. Colgan & Scully do not explain the presence in Ireland of these plants as being due to any such accidental transport. They believe them to have reached Europe by means of an ancient northern land-connexion. Mr. Praeger likewise comes to a similar conclusion with regard to the origin of the American plant group in Ireland. He does not favour the theory of accidental dispersal. A land surface, long since destroyed, of Pre-Glacial age, appeals to him as a more likely explanation of the presence of the American plants.[4]

The number of plants common to Europe and North America is really far greater than we imagine, though very few, as we have seen,

[1] James Geikie, *Prehistoric Europe*, 1881, p. 520.
[2] E. von Drygalski, *Grönland Expedition*, 1897, vol. i, p. 335.
[3] N. Colgan & R. W. Scully, *Cybele Hibernica*, 1898, 2nd ed., p. 71.
[4] R. Ll. Praeger, *Irish Topographical Botany*, 1901, p. 23.

are quite confined to these continents. Of those which also occur in Asia there are many, like the Orchid *Listera cordata*, which grows only in a few localities in the extreme east, that are apparently absent from the greater part of the continent. It is probable that all these have found their way from America to Europe by a direct passage. Moreover, we know from Professor Drummond's researches that of seventy species of fossil plants observed by him in the Pleistocene clays of Toronto in Canada, twenty occur at the present day both in that country and in Europe.[1] This seems to indicate that during the Pleistocene period, the great mass of the flora common to America and Europe had already found its way from the one continent to the other.

The zoological testimony in support of this view is of a more pronounced character. The interest aroused in Ireland by the discovery of the American plants has led to research in other directions. Thus, in 1895, three species of freshwater sponges were detected in various lakes at some distance from the sea on the west coast. Only one of these sponges, viz. *Tubella pennsylvanica*, has since been observed in another European locality, in Loch Baa in Scotland, but all of them are identical with American species.[2] Dr. Hanitsch identified them as *Ephydatia crateriformis*, *Heteromeyenia Ryderi*, and *Tubella pennsylvanica*.

In my more recent work on European Animals, I have incidentally dwelt on the past range of the Great Auk (*Alca impennis*) as indicating the presence of a former more continuous coastline between the British Islands, Iceland, Greenland, and Newfoundland, in all of which countries this bird was known to have been abundant.[3] Yet, after all, the best evidence in favour of a North Atlantic land-bridge is furnished by the invertebrates. Our special attention is drawn by Mr. Born to the importance of the 'Running Beetles' of the genus *Carabus*. From the fact of their being wingless and usually found under stones or clods of earth, they are not liable to be transported accidentally by any of the means usually supposed to aid animals in their dispersal. Mr. Born claims that at least two European species of *Carabus*, viz. *C. catenulatus* and *C. nemoralis*, have crossed the Atlantic by means of an ancient land-bridge. A third form—*Carabus groenlandicus Chamissonis*—seems to have originated in America, and to have travelled from there to Greenland and Lapland.[4]

Of another group of insects—the Collembola—Professor Carpenter remarks: "It is of interest to find that the presence of not a few species of these wingless insects in America, in Greenland, in the islands to the north of Europe and Asia, and on the Euro-Asiatic continent, lends support to our belief in a Pliocene or Pleistocene

[1] A. T. Drummond, "Plants common to Europe and America": *Nature*, 1904, lxx, p. 55.

[2] R. Hanitsch, "Freshwater Sponges of Ireland": *Irish Nat.*, 1895, iv, p. 126. Annandale, "Freshwater Sponges in Scotland": Journ. Linn. Soc. (Zool.), 1908, xxx.

[3] R. F. Scharff, *European Animals*, 1907, pp. 37–9.

[4] Paul Born, "Carabologische Studien": *Entomol. Wochenblatt*, 1908, xxv, pp. 8, 9.

land-connexion to the north of the Atlantic Ocean—a belief already upheld by so much evidence, both geological and zoological."[1]

Quite a number of naturalists believe that any resemblance between the European and the American fauna must have arisen, not from any direct intercourse between Europe and America, but by a migration across Asia and a Bering Strait land-connexion. The supposition of an ancient northern Pacific land-bridge presents fewer difficulties to them than the Atlantic one, and is preferred for that reason. Dr. Horváth, for example, who states that no less than 128 species of Hemiptera are common to the two continents, argues that they all must have crossed Asia in reaching the one from the other.[2] But he and those who agree with him were apparently unaware that certain freshwater species common to Europe and America are almost totally absent from Asia or Western America.

Let us take, for example, our common Perch (*Perca fluviatilis*), a variety of which also inhabits North America. It is absent not only from a large part of Asia, but also from Western North America. Certainly this looks like a case of direct migration from America to Europe.

Another example that I have had occasion to quote in my work on *European Animals* (p. 35) is the freshwater Pearl-Mussel (*Meleagrina margaritifera*). On our continent it inhabits the British Islands except Eastern England, the mountain streams of Scandinavia, and the hill-region of Central Europe except the Alps. Far to the east it reappears in a different form in the River Amur in Eastern Siberia, in the island of Sakhalin, and in Kamchatka. Another variety is met with across the Bering Strait in Alaska and in Western North America generally. The type form occurs in the Quebec province of Canada, in the Lower Saskatchewan River, and in New England. The typical freshwater Pearl-Mussel is only met with in Eastern North America and in Central and North-Western Europe. America is undoubtedly its original home. From it the mussel spread to Europe in an eastward direction, and not by way of Asia. As the fry of these mussels attach themselves to the gills of fishes, they are liable to wide dispersal within at least one river system; but fishes in this case could scarcely have aided them in reaching Europe. A land-connexion between the two continents explains their distribution certainly better than any other theory.

The most striking piece of evidence we possess in favour of a Pre-Glacial land-connexion between North-Western Europe and North-Eastern North America is the presence in the latter country of the snail *Helix hortensis*.

A western species in Europe, *Helix hortensis*, is remarkable for its extensive northern range. It occurs in Scandinavia, all over the British Islands, in the Shetlands and Faröes, and even in Iceland. It is altogether absent from Asia. Its occurrence in Southern

[1] G. H. Carpenter, "Collembola from Franz Joseph Land": Proc. R. Dublin Soc., 1900, ix, p. 276.

[2] G. Horváth, "Faunes hémiptérologiques": Ann. Hist. Nat. Mus. Hungarici, 1908, iv, pp. 4–7.

Greenland had generally been attributed to a recent human introduction; but it has been taken in several different localities, and we must, I think, look upon it as an indigenous species. During the year 1864 Professor E. S. Morse discovered the shell of this snail among ancient 'kitchen-middens' on some of the islands off the coast of Maine. This fact led him to consider that the snail had wandered along some ancient coastline from the Old World across the North Atlantic. Dr. Binney, and more recently Professor Cockerell, concurred with Professor Morse's opinion, while the Rev. Mr. Winkley even suggested that *Helix hortensis* arrived in North America before the advent of the Glacial period. With the latter theory Mr. Johnson, another conchologist, expressed his agreement; and it is to his paper that I am indebted for the above-mentioned information.[1]

All doubts as to the claim of *Helix hortensis* being an indigenous American species are now set at rest through the discovery by Dr. Dall of the shell of this snail in undoubtedly Pleistocene deposits in the State of Maine.[2] Moreover, the species is now known to inhabit a much greater area than was formerly supposed; for it has been collected in Labrador, Newfoundland, Prince Edward Island, and many other small islands where it could not possibly have been brought by man. It may, therefore, be considered as definitely established that *Helix hortensis* reached America in Pleistocene or Pliocene times without human intervention.

The discovery of *Helix hortensis* in Greenland is an important factor in favour of the land-connexion theory. That this species should have survived the Glacial period in that country need not surprise us; for several other species of land and freshwater molluscs certainly must have done so. *Planorbis arctica*, *Limnæa Vahli*, *L. Wormskioldi*, *Succinea grœnlandica*, *Vitrina angelicæ*, *Pupa Hoppii*, and *Conulus Fabricii* are almost all confined to Greenland, and no doubt originated there in Pre-Glacial times.

Of all the theories which have been advanced in explanation of the occurrence of identical species on both sides of the Atlantic Ocean, only the following three have met with wide approval:—

1. Migration from Europe across Asia and a Bering Strait land-bridge to America or vice versa.
2. Occasional transport by birds across the Atlantic Ocean.
3. Migration across a direct Atlantic land-connexion.

If we consider the zoological evidence alone, namely, the absence of *Helix hortensis* from Asia and Western America, the distribution of the Perches and the freshwater Pearl-Mussel, and that of the freshwater Sponges, the first of the three hypotheses is scarcely applicable to these instances of distribution, and does not, therefore, explain the presence of identical species on both sides of the Atlantic in a satisfactory manner.

As regards the supposed conveyance by birds of seeds and invertebrates across the same ocean, the second theory must be

[1] C. W. Johnson, "Distribution of *Helix hortensis*": *Nautilus*, 1906, xx, p. 73.

[2] W. H. Dall, "Land and Freshwater Mollusks": Harriman Alaska Exped., 1905, xiii, p. 20.

applicable to a transport in two directions, both from America to Europe as well as vice versa.

The fact that both in America and Europe the indigenous species of plants and animals identical to the two continents are largely confined to the coast region may appear at first sight in favour of the theory of introduction by birds. Almost all the American plants, and all the American freshwater sponges at any rate, occur in the vicinity of the coast. It has been argued, therefore, that, after their long flight across the ocean, birds would naturally alight on the earliest opportunity; and that it was for this reason that the plants and animals common to the two continents were so largely confined to the coastal districts. But from what has been mentioned we have no reason to infer that American birds do habitually alight on the west coast of Ireland on first reaching Europe. It seems highly probable that they cross by way of Greenland. We should, therefore, expect all species of the invertebrates and plants common to the two continents to be found in Greenland as well. This is not so. Only comparatively few of them are met with in Greenland. The theory that the resemblance in the fauna and flora of Eastern North America and Western Europe is due to the action of birds is, I think, not supported by sufficient evidence.

The third theory, that the identical species on either side of the Atlantic Ocean are the result of a direct land-connexion between Scotland, Iceland, Greenland, and Labrador, appears to me to be well founded on geological, bathymetrical, and biological evidence. No decisive testimony, however, has as yet been brought forward to show during what geological period this land-bridge was formed and how long it lasted. The assumption that such geographical conditions prevailed during early Tertiary times is very widespread. That this state continued during the Miocene period is likewise maintained by many; though Professor Dawkins and a few others do not admit the existence of the northern land-bridge in Pliocene or more recent times.[1] Sir Archibald Geikie's researches point to the production of the great basalt plateaux of North-Western Europe in early Tertiary times. These plateaux formed a continuous tract of land, as far as the Faröes at any rate. He proves that in many places, such as Iceland, the Faröes, and the West of Scotland, enormous subsidence subsequently took place.[2]

Once we admit that animals and plants were able to survive the Glacial period in northern latitudes, a land-connexion such as suggested in Pliocene times would readily account for the presence of all the animals and plants common to Europe and America. By many of those best able to judge, an admission to that effect has been made. Pliocene deposits are scanty in the British Islands; yet they yield valuable suggestions as to the geographical conditions of the North Atlantic. An examination of the fossil invertebrates contained in the St. Erth Beds in Cornwall, which are of Pliocene age, showed that the fauna possessed a remarkably southern facies, and that there was

[1] W. Boyd Dawkins, *Early Man in Britain*, 1880, p. 43.

[2] A. Geikie, "Basalt Plateaux of North-Western Europe": Q.J.G.S., 1896, lii, p. 405.

a total absence of boreal or Arctic species. This fact led Professor Kendall and Mr. Bell to the conclusion that at the period during which these deposits were laid down—that is to say, during the latter part of the Pliocene period—no channel or direct communication existed between the North Sea and the Atlantic Ocean, the Straits of Dover being closed in the south, while in the north the Tertiary volcanic chain formed a barrier across from the North of Scotland to Greenland by way of the Shetland Islands, Faröes, and Iceland.[1]

Mr. Reid's contention that the St. Erth Beds are older than Messrs. Kendall & Bell estimated—that they are, in fact, of early Pliocene age—is founded chiefly on the circumstance that the percentage of extinct species is about the same as that of the Coralline Crag. The consideration of the supposed climatic conditions does not seem to me of any particular value; and, as he remarks, the exact age of the clays is still doubtful.[2] Even if the St. Erth Beds belong to the lower Pliocene, there are no grounds for the supposition that the northern barrier, alluded to by Messrs. Kendall & Bell, had ceased to exist in later Pliocene times.

The change in the Pliocene fauna of the east coast of England, as we pass from the older to the newer beds, no doubt implies, as Mr. Harmer pointed out, an opening up of the area to the influence of the northern seas.[3] But we do not possess the slightest evidence for the assumption that the Atlantic Ocean was similarly affected. Many of the facts, indeed, lead to the conclusion that the land on the Atlantic coasts of the British Islands stood highest in late Pliocene and early Pleistocene times, and that it was then that *Helix hortensis* and many other European species must have made their way to America.

Glacial conditions prevailed at this time on all the high mountain ranges surrounding the warm Atlantic Ocean, and yet the coast region must have supported an abundance of animal and plant life. The presence of a land-bridge between Scotland and North America by way of Greenland, and another between England and France, would have excluded the Gulf Stream from the Arctic regions. Professor Blytt's argument that under such conditions all the coast region, including Iceland and Southern Greenland, would have had a higher temperature than at present, while the lands beyond were probably colder, seems irrefutable.[4] Yet Professor James Geikie believes that even the latter countries would then have had a more genial climate.[5]

In my opinion it was during this epoch, in Pre-Glacial times, that the interchange between the fauna and flora of North-Western Europe and North-Eastern America was effected across the northern land-bridges.

Only one other point needs to be commented upon. I have shown

[1] P. F. Kendall & A. Bell, "The Pliocene Beds of St. Erth": Q.J.G.S., 1886, xlii, pp. 206, 207.
[2] C. Reid, *Pliocene Deposits of Britain*, 1890, p. 61.
[3] F. W. Harmer, "Pliocene Deposits of Holland": Q.J.G.S., 1896, lii, p. 754.
[4] Abel Blytt, "Theorie d. wechselnden Klimate": Engler's *Botanische Jahrb.*, 1881, ii, p. 49.
[5] James Geikie, *Prehistoric Europe*, 1881, p. 520.

that most of the American species occupy the Atlantic coast region in the British Islands. Almost all the southern or Lusitanian species are found in precisely the same area in England, Ireland, and Scotland. This seems to me partly due to the fact that the temperature was considerably higher there during the Glacial period than in the more inland localities. Even now the plants are under more favourable climatic conditions on the west coast than further inland, and less exposed there to competition with the stronger eastern rivals. Moreover, almost the whole of Ireland and a large portion of England are thickly swathed in a mantle of Glacial clay. We can only suppose that the forces which controlled the deposition of this clay were less effective on the west coast, which may have extended far to the west of its present boundary, and have thus given rise to the preservation of many species of animals and plants which were destroyed elsewhere.

REVIEWS.

I.—Geological Survey of Great Britain.

1. The Geology of the Seaboard of Mid Argyll, including the Islands of Luing, Scarba, the Garvellachs, and the Lesser Isles, together with the northern part of Jura and a small portion of Mull. By Dr. B. N. Peach, F.R.S., H. Kynaston, and H. B. Muff [Maufe]; with contributions from S. B. Wilkinson, J. S. Grant Wilson, J. B. Hill, A. Harker, F.R.S., E. B. Bailey, and petrological notes by Dr. J. S. Flett. 8vo; pp. vii, 121, with 7 text-illustrations and 8 plates. Glasgow, 1909. Price 2*s*. 3*d*.

We cannot refrain from a feeling of sympathy with librarians, who give cross-references in their catalogues, at the lengthy title and array of authors and contributors imprinted in this memoir. The field-work, however, has been carried out by many hands in a very diversified region, comprising a number of islands and parts of islands, together with the western seaboard of Argyllshire, from Easdale and Kilmelfort on the north, to the plateau beyond the Crinan Canal on the south.

Nearly the whole of the area described is made up of various metamorphic rocks, including the Craignish and Ardrishaig Phyllites, the Easdale Slate and Limestone Group, and the Quartzite Group, together with epidiorites. No less than fifty-two pages are given to the description of these rocks, and of the folding, metamorphism, the crush-conglomerates, and thrust-planes; while the subject is illustrated by remarkable photographs of pseudo-conglomerate and strain-slip cleavage, of folds, boulder-beds, and phacoids of epidiorite.

Rocks of Lower Old Red Sandstone age occur on the mainland north of Loch Melfort, and in the islands of Seil and Lunga; and they consist mostly of andesitic lava-flows, with here and there some shales, grits, and conglomerates, as well as tuffs and agglomerates. There occur also masses of diorite and granite, together with dykes and sills of other intrusive rocks, and these, with the effects of contact metamorphism, are duly described.

Brief reference is made to the Tertiary igneous rocks of Mull, which comprise basaltic lavas, for the most part amygdaloidal, and intrusive sills of olivine-dolerite, that make strong features and possess columnar jointing. Dykes of Tertiary dolerite and basalt are numerous throughout the entire area; and these, which are described in some detail, include teschenites, tholeiites, andesitic pitchstone, and camptonite. Altogether, with the chapters on Old Red and Tertiary rocks, the petrographical portion of the memoir extends over eighty pages.

The higher grounds on the mainland, though glaciated, are comparatively free from superficial deposits, but evidence is given of the westerly seaward passage of an ice-sheet, which at one time filled the sounds and sea-lochs and overrode the outer islands, rising in Scarba and Jura in places to a greater height than any part of the mainland. Numerous small freshwater lochs occupying rock-basins owe their origin to the ice-erosion.

Raised beaches indicate that the area has undergone periodic elevation since Glacial times to the extent of about 100 feet; but it is mentioned that the contour-lines, which are continued "to a depth of 200 feet below Ordnance datum level, show that the floors of the different sea-lochs, and of the Sounds of Luing, Shuna, and Seil are studded with basins which, were the land upheaved to the extent of 200 feet, would form lochs much larger in area than any existing on the present land surface".

The inference is that the land was elevated to that extent or more during the Glacial period, and subsequently depressed, so that despite the final elevation of 100 feet, indicated by the Raised Beaches, "the promontories, islands, and skerries represent the hill-tops and dividing ridges between the drowned valleys."

The chapter on economics contains an important account by Mr. Maufe of the roofing-slates of Easdale, which have been systematically worked since 1748. It is interesting to note that while most of the best slates are characterized by small cubes of pyrites, some of the slates in which the iron sulphides are in a finely disseminated state are liable to decay.

2. The Geology of the South Wales Coal-field. Part I: The Country around Newport, Monmouthshire. By Aubrey Strahan, Sc.D., F.R.S. Second Edition. 8vo; pp. x, 115, with 6 text-illustrations and 1 plate. London, 1909. Price 1*s.* 6*d.*

TEN years have elapsed since we called attention (Geol. Mag., 1900, p. 86) to the first edition of this memoir, which was also the first publication relating to the re-survey of the geology of the South Wales Coal-field. The six-inch survey of the great coal-field, commenced in 1891, has been conducted and now completed under the personal superintendence of Dr. Strahan.

In this second edition of the Newport memoir the geological information relating to the area has been brought up to date; and of especial importance are the records of new coal-borings. A useful map has been added showing thicknesses of the Pennant Grit and Lower Coal Series at different localities.

In the former edition of the memoir attention was called to the sharp plane of demarcation between the Silurian and Old Red Sandstone. It is now known that the Tilestones (passage-beds) and underlying minor Silurian divisions, met with 40 miles further west, are not present in the Usk district, unless represented by strata of wholly different characters. The list of Silurian fossils has been revised, and the nomenclature in the earlier edition modified in a way that may be said to render comparisons odious.

The Old Red Sandstone is now separated into Upper and Lower divisions, with the Brownstones in the upper part; but no evidence of unconformity in the formation has been detected.

Some observations have been made by Mr. E. E. L. Dixon on the zonal divisions in the Carboniferous Limestone of the Newport area, and the absence of the higher portions of the Limestone Series is attributed to the unconformable overstep of the Millstone Grit.

II.—Cretaceous of Poland.

FROM a series of papers extracted from *Kosmos* (Lemberg), 1909, vol. xxxiv, we gather that Jan Nowak describes the Cephalopod fauna of the uppermost Senonian (Campanian) of the Carpathians. The fauna was collected by Professor R. Zuber in Galicia and includes such well-known forms as *Baculites anceps*, Lam., *Scaphites constrictus*, Sow., *S. tenuistriatus*, Kner, and *Belemnites bipartitus*, Bl. With these occurs a form called "*Inoceramus Cripsi*, Mant." This unfortunate species seems to give endless trouble to Continental authors, and it may as well again be stated that the type in the British Museum is an internal cast, without any shell whatever, and came from the Chalk Marl of Offham. In England it is certainly a Cenomanian fossil, and there is nothing like it in the higher beds. Dr. Zuber describes the stratigraphy and tectonics of the Galician Carpathians in the same volume, and after an appropriate summary of previous authors, gives a lucid sketch of the geology, illustrated with many sections. But here also *Inoceramus Cripsi* is associated with *Belemnitella mucronata*, which seems an impossible thing to those who know the fauna of the Chalk of England. Dr. W. Rogala, who discusses this very point in a communication to the same volume, says on p. 742 of his paper: "Wszystkie formy z Lopuszki W. dadza sie pomiesoic w obrebie gatunku *Inoceramus Cripsi*, Mant., jaki temu gatunkowi nadal Zittel. Nowsze jednak badania Petraschecka wykazuja, ze formy gosawskie sa weale rozne od oryginalu Mantell' a, a badania J. Bohma wykazuja rowniez, ze i formy Goldfussa sa od niego rozne; wobec tego obydwaj ci autorowie nazwe *I. Cripsi*, Mantell zaciesniaja, a liozne formy dotychczas nia obejmowane oddzielaja jako osobne gatunki," and omits *I. Cripsi*, Mant., from his list on p. 745, using the name *I.* (cf.) *regularis*, d'Orb., instead.

Other interesting papers in this volume are on the fish fauna of the menilit-beds (Lower Oligocene) of the Carpathians, by Jan Rychlioki, and one on the Titonian Klippen at Kruhel Wielki, near Przemysl, by Dr. Zuber. These seem to be composed of foundered Inoceramus-bed, with exotic blocks of Stramberger Titonian.

C. D. S.

REPORTS AND PROCEEDINGS.

November 17, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Geology of Nyasaland." By Arthur R. Andrew, F.G.S., and T. Esmond Geoffrey Bailey, B.A., F.G.S. With a Description of the Fossil Flora, by E. A. Newell Arber, M.A., F.G.S.; Notes on the Non-Marine Fossil Mollusca, by Richard Bullen Newton, F.G.S.; and a Description of the Fish-Scales of *Colobodus*, etc., by Ramsay Heatley Traquair, M.D., F.R.S., F.G.S.

(1) The greater part of Nyasaland consists of crystalline rocks, which comprise—

(*a*) Highly metamorphosed sedimentary beds, including graphitic gneisses with limestone, and muscovite-schists.

(*b*) Foliated igneous rocks, especially augen-gneiss, derived from granite or syenite.

(*c*) Plutonic intrusions, usually granite or syenite, more rarely gabbro. In two localities nepheline and sodalite-syenites are found; these are perhaps of the same age as the similar post-Waterberg and pre-Karoo syenites of the Transvaal.

(2) In the north-western corner of Nyasaland is a somewhat altered sedimentary series, which forms the Mafingi Hills. It consists of a thick accumulation of quartzites, grits, and sandstones of pre-Karoo age.

(3) The Karoo System is represented both in the north and in the south of Nyasaland; in the north it occurs in patches, which owe their preservation to faulting. It has afforded remains of freshwater lamellibranchs (*Palæomutela*), fish-scales (*Colobodus*), and species of *Glossopteris*.

(4) Recent lacustrine marls and sands are found at great heights above the present level of the lake, and as much as 15 miles away from its margin.

(5) Pumiceous tuffs, associated with recent gravels containing pebbles of Tertiary lava, are found in the extreme north of the country; across the border, in German East Africa, Tertiary and recent lavas and tuffs are widely distributed.

(6) Nyasaland consists of high plateaux rising irregularly one above the other. The Nyika and Vipya plateaux were doubtless at one time continuous as "a platform of erosion", which originated after the main faulting of the Karoo in Northern Nyasaland, and before the formation of the great Nyasa fault trough.

2. "The Faunal Succession of the Upper Bernician." By Stanley Smith, M.Sc., F.G.S.

The Bernician Series forms the upper and by far the larger division of the Lower Carboniferous sequence of Northumberland, and covers the greater part of the county. Below the Bernician lie the Tuedian

Beds. The Northumberland succession, together with the Lower Carboniferous rocks north of the Tweed, occupies the northern extremity of the Pennine Province of the Carboniferous Limestone Series, which stretches from Staffordshire into Scotland. The Carboniferous strata in Northumberland encircle the Cheviots on the south, east, and north, and dip from the volcanic inlier, so that the general strike forms a rough semicircle round the igneous massif, nearest to which consequently lie the lowest beds.

The Bernician is mainly built up of sandstones and shales, but intercalated among the arenaceous and argillaceous deposits are the various beds of limestone and numerous seams of coal.

In the Upper Bernician, the limestones are fairly thick, are constant, and are truly marine. The calcareous beds of Lower Bernician age are thin and impure, and frequently contain *Stigmaria* and other plant-remains. There are a few good marine limestones, but these are of local occurrence.

The Upper Bernician, taking the Redesdale Ironstone Shale as the base, answers to Tate's Calcareous Group; while the Lower Bernician is equivalent to Tate's Carbonaceous Group.

It is with the Upper Bernician only that the present paper is concerned.

The whole of the Upper Bernician Limestones belong to the *Dibunophyllum*-zone, but they are capable of the following palæontological subdivisions :—

a = Redesdale Ironstone Shale.
Shallow-water fauna, mainly lamellibranchs ; corals rare.
Dibunophyllum near θ has been found.

I = Redesdale Limestone.
D 1 fauna.
Dibunophyllum θ.
Carcinophyllum θ especially characteristic.

II = Fourlaws and Oxford Limestones.
D 2.
Lonsdalia floriformis enters.

III = Eelwell, Acre, and Four Fathom Limestones.
D 2–3 presents in its main character a Zaphrentid phase.

IV*a* = Great and Little Limestones.
D 3.
Dibunophyllum muirheadi.
Koninckophyllum magnificum.
Diphyphyllum dianthoides.

IV*b* = Corbridge, Thornbrough, and Robsheugh Limestones.
The tendency in the Dibunophyllids towards Aspidophylloidal structure reaches its highest development.

IV*c* = Fell Top Limestone.
Characterized by the presence of *Dibunophyllum muirheadi* mut., cf. *Dibunophyllum* ψ, and *Phillipsastræa radiata*.

3. "Notes on the Dyke at Crookdene (Northumberland), and its Relations to the Collywell, Morpeth, and Tynemouth Dykes." By Miss M. K. Heslop, M.Sc., and Dr. J. A. Smythe. (Communicated by Professor G. A. Lebour, M.A., D.Sc., F.G.S.)

The dyke at Crookdene is exposed in the bed and banks of the

Wansbeck about 15 miles above Morpeth. It is intruded along a fault-fissure in beds of Bernician age, and apparently comes to a natural head. The basalt is characterized, microscopically, by narrow lath-shaped felspars and curved augites. Macroscopically, its most interesting feature is the occurrence of large inclusions of a felspar, which is shown by chemical analysis to be closely allied to anorthite. The exterior of the inclusions in contact with the ground-mass is strongly zoned, the latter showing a slightly chilled edge; the individual crystals are intergrown and are cracked, faulted, and in places completely shattered. In no case is the dislocation great, and, in fact, the crystals seem to have burst in situ. These phenomena point to a plutonic origin of the felspathic inclusions and connect them with the porphyritic felspars of the Tynemouth Dyke, for which a similar origin has already been suggested by Dr. Teall.

The dyke which comes to a head in the coast-section at Collywell, about 24 miles distant, shows almost precisely the same peculiarities. Chemical and microscopical examination of the two basalts and their felspathic inclusions show them to be practically identical. Considering these facts and the general field-relationships of the dykes, it appears probable that they belong to the same intrusion.

The work of Dr. Teall upon the dykes at Tynemouth and Morpeth has been amplified by further observations. The resemblances among the four dykes are so strong as to render it probable that they are derived from a common source. The observed differences are such as could be readily accounted for by differences of physical condition operating during the period of consolidation of the dykes.

December 1, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Tremadoc Slates and Associated Rocks of South-East Carnarvonshire." By William George Fearnsides, M.A., F.G.S., Fellow of, and Lecturer in Natural Sciences at, Sidney Sussex College, Cambridge.

This paper gives the results which have been obtained by the author in making a detailed map of the country about Portmadoc, Tremadoc, and Criccieth in Carnarvonshire, and describes the stratigraphy of the Cambrian and Ordovician rocks there exposed. The area described includes the original type-area of the Tremadoc Slates (Sedgwick & Salter), and the paper includes a detailed account of the local development of this well-known series.

The first part of the paper is devoted to a brief summary of the results attained by former workers, and is arranged to show the various stages through which the nomenclature of the major subdivisions of the Cambrian and Ordovician Systems have evolved.

The sedimentary series are described in the order of their formation. The succession may be tabulated as follows:—

	Western or Criccieth District.	*Eastern or Tremadoc District.*
Caradoc Series.	Rhyolitic ashes and agglomerates. Variable dark-grey and black shivery slates, banded, but with no distinguishable horizons.	Grey slate series, often strongly banded, with a few shelly fossils (*Trinucleus* and *Orthis*) in the upper part.
Llandeilo Series.	Dark banded slates with intense cleavage; no fossils found. Earthy slates, with occasional 'tuning-fork' graptolites.	Andesitic ashes and ashy shales. Vesicular andesites. Blue-black slates containing graptolites. Zone of *Nemagraptus gracilis.*
Arenig Series.	Shivery slates passing down into Flaggy grits yielding *Calymene parvifrons.* Basal conglomeratic grit.	Conglomeratic grit of Ynys Towyn.

Unconformity.

Tremadoc Series.	Garth Hill Beds: Grey-blue slates with *Angelina.* Penmorfa Beds: Flaggy mudstones and thinly-bedded slates, with *Shumardia* and the Shineton fauna. Portmadoc Beds: Thickly-bedded felspathic slates, with occasional *Asaphellus.* Moel-y-gest Beds: Banded grey slates and mudstones; few fossils, *Acrotreta* and *Bellerophon.* The *Dictyonema* Band: A constant and characteristic band of bright rusting blue-grey mudstones, with abundant *Dictyonema sociale.* Tynllan Beds: Thinly-bedded rusty shales with some hard grey mudstone bands, containing *Niobe* and *Psilocephalus.* (*Symphysurus.*)	Not complete in the area studied.
Dolgelly Series.	Sooty-black mudstones with *Peltura scarabæoides.* Blue-black mudstone with *Agnostus trisectus.* Black slates, with calcareous bands often crowded with *Orthis lenticularis.* Dark flaggy slates with *Parabolina spinulosa.*	
Ffestiniog Series.	Grey-blue slates and flags crowded with *Lingulella davisii.* Grey flags and grauwacké with some coarser bands (1800 feet thick).	
Maentwrog Series.	Rusty grey and blue slates, with thin bands of felspathic grauwacké.	

The folding, the cleavage, the faulting, and the jointing of the rocks are described, and an attempt is made to show some relationship between the various stress-phenomena which have produced these structures.

The great fault through Penmorfa is interpreted as a thrust-plane hading gently to the north-east. It is described as bounding two districts which are of a very different structural type, and is supposed to form the lowest sole of the group of thrust-planes which follow the southern margin of the Snowdonian mountain-tract.

The well-known pisolitic iron ore of Tremadoc is shown to follow the line of this fault, and is thought by the author to be of the nature of a metasomatic veinstone.

Direct evidence of overthrusting has been got from a study of the graptolite-bearing Llandeilo rocks of Tyddyn-dicwm, which have been exposed in two artificial trenches dug for the purpose; and the distribution of the andesitic volcanic series in lines of detached lenticles among the Grey Slates is described as evidence of a similar reduplication of the newer series of the north-eastern district on a more extended scale.

The actual lines of major thrust-planes, other than the Penmorfa Fault, have not been discovered; but, from the broad-spreading character of the sills of gabbroid dolerite, the author infers that these have come in along the thrust-planes.

The petrographical characters of these quartziferous and hypersthene-bearing dolerites are not dealt with, but it is noted that the dolerites are (1) unaffected by cleavage and faulting; and (2) have metamorphosed rocks which were already cleaved, cut, and reduplicated by the thrust-faulting at the time of their intrusion: in this the author joins issue with previous observers in regard to their age.

The Glacial and post-Glacial accumulations are also described in outline.

2. "On some Small Trilobites from the Cambrian Rocks of Comley (Shropshire)." By Edgar Sterling Cobbold, F.G.S.

The majority of the trilobites noticed in this communication were obtained during the progress of some of the excavations referred to in the Report of the Geological Excavations Committee of the British Association, read at the Dublin Meeting, 1908.

The specimens were derived from the *Olenellus* Limestone of Comley, and from the Grey Limestones which intervene between that horizon and the Conglomeratic Grit yielding a *Paradoxides* fauna.

The author notices the occurrence of *Microdiscus lobatus*, Hall, *M. speciosus*, Ford, *M. helena*, Walcott, and *Ptychoparia* (?) *attleboroughensis*, S. & F. He describes eleven species, apparently new, which he refers to the genera *Microdiscus*, *Ptychoparia*, *Micmacca* (?), *Agraulos* (*Strenuella*), *Anomocare* (three species), *Protolenus* (two species), and two species to a new genus, to which Mr. Matthew's species *Micmacca* (?) *plana* may also be referred.

All the trilobites are represented by detached portions or fragments, often mixed indiscriminately, two or three species together, in the separate bands of rock; and the author adduces in some detail the evidence for correlating certain free cheeks, thoracic segments, and pygidia with the various head-shields, so that future workers may clearly distinguish between that which is actual fact and that which is a matter of inference.

3. "The Rocks of Pulau Ubin and Pulau Nanas (Singapore)." By John Brooke Scrivenor, M.A., F.G.S.

Pulau Ubin and Pulau Nanas are islands set in the eastern entrance to the Straits of Jahore, and consist of igneous rocks of considerable interest. Pulau Ubin is composed mainly of hornblende-granite, but a pyroxene-bearing microgranite is found also; while the hornblende-granite is cut by rhombic-pyroxene bearing veins and also contains angular masses of rock resembling the veins.

The following grouping of the Pulau Ubin rocks (with which is included a rock found in the granite of Changi) is adopted.

I.

Normal hornblende-granite with a little monoclinic pyroxene.

II.

Pyroxene-microgranite with dark masses resembling III (i).

III.

(i) Porphyry, with peculiar spongy masses of hornblende.
(ii) Masses of a rock at Changi having the mineral constitution of an amphibole-vogesite.

IV.

(i) Veins of quartz-norite in the normal granite.
(ii) Veins and masses of enstatite-spessartite in the normal granite.
(iii) Masses of quartz-biotite-gabbro in the normal granite.

Pulau Nanas consists of dacite-tuffs and dacite which are referred to the Pahang Volcanic Series, of Carboniferous or Permo-Carboniferous age. The tuffs and lavas have been altered by the adjacent granite of Pulau Ubin, and contain much secondary biotite and hornblende. They also contain some fragments that appeared to be altered chert, but their most remarkable feature is the presence of fragments of altered granite.

The author discusses the mutual relations of the different rocks, and arrives at the following conclusions:—

(1) The normal granite of Pulau Ubin is hornblende-granite, the age of which is certainly post-Triassic and pre-Eocene, perhaps post-Inferior Oolite and pre-Cretaceous.

(2) Veins of quartz-norite and masses of quartz-biotite-gabbro, and veins and masses of a fine-grained rock which may be described as enstatite-spessartite, are found in the normal granite of Pulau Ubin. These point to an early differentiation of a granite and a gabbroid magma, perhaps in pre-Cretaceous times, and they are referable to rocks in Borneo and Amboyna.

(3) A pyroxene microgranite and porphyry on Pulau Ubin, and a rock at Changi, having the mineral constitution of an amphibole-vogesite, are described. Their relations to the other rocks are not clear.

(4) The dacite-tuffs of Pulau Nanas contain fragments of granite which must be of pre-Carboniferous age, and are referable to the granite of Amboyna.

(5) The fragments of granite, and perhaps certain pebbles of schorl-rock, are the only evidence found as yet in the Malay Peninsula of pre-Carboniferous rocks.

4. "The Tourmaline-Corundum Rocks of Kinta (Federated Malay States)." By John Brooke Scrivenor, M.A., F.G.S.

Overlying the limestone on the west side of the Kinta Valley is a thin cap of schists, with which are found certain rocks the two chief constituents of which are tourmaline and corundum. They are often carbonaceous; and, in the many variations found, white mica, brown mica, pleonaste, rutile, and metallic sulphides occur.

The tourmaline-corundum rocks contain certain structures which are described in detail. These consist of round and oval cavities and bodies, the largest of which are about 6 millimetres in greatest width. Nothing can be proved regarding their origin, but the description of the rocks is summarized and a hypothesis adopted regarding their history, as follows :—

(1) The tourmaline-corundum rocks of Kinta consist of varying amounts of tourmaline, corundum, carbon, white mica, spinel, and other minerals.

(2) They contain cavities about 6 millimetres in greatest width, generally bordered by a layer of corundum grains, with tourmaline grains on the inside of this border. Sometimes solid bodies similar in size and shape to the cavities occur. They are composed of tourmaline and corundum, the former mineral, generally speaking, being more abundant towards the centre. Such bodies also show concentric structure.

(3) Smaller bodies occur, sometimes, but not always, accompanied by the larger cavities and bodies. They consist of tourmaline, of corundum, and of tourmaline and corundum. When both minerals are present, the corundum forms a shell to a nucleus of tourmaline. The corundum bodies frequently show concentric structure.

(4) The tourmaline-corundum rocks are associated with other rocks, which lead to the conclusion that the structures described in (2) and (3) are the result of replacement of the materials of pre-existing bodies at the time of extensive granitic intrusions.

(5) They also are associated with rocks which point to the original beds having been laid down under conditions similar to those that obtained when the Pahang Chert Series was deposited.

(6) As tourmaline-bearing partings in the limestone at Changkat Pari constitute a case of selective metamorphism, so it is thought that the tourmaline-corundum rocks as a whole mark a process of selective and intense metamorphism in beds associated with schists overlying the Kinta Limestone.

(7) These beds were probably chert and silicified limestone, both being in many cases carbonaceous.

(8) The larger cavities and bodies mentioned in (2) are believed to be the result of replacement or partial replacement of oolitic grains.

(9) The smaller bodies may be, in part, the result of replacement of the materials forming casts of radiolarian structures; in part, the result of the further development or replacement of spots seen in soft partings in the limestone at Changkat Pari; and in part, the result of the replacement of small oolitic grains.

OBITUARY.

HILARY BAUERMAN,

Assoc. M. Inst. C.E., Assoc. R.S.M., F.G.S.

Born 1833. Died December 5, 1909.

The closing days of the old year have gathered in another prominent geologist and fellow-worker to his well-earned rest, leaving our science the poorer, and ourselves to regret his loss. Of Hilary Bauerman's early days we are not informed, but in 1851, at the age of 18, he became a student at "the Government School of Mines and of Science applied to the Arts", Jermyn Street, where he had the advantage of studying under Playfair, Ramsay, Forbes, Warington Smyth, Hunt, and Percy. It was specially due to the personal influence exercised by Dr. Percy and Sir Warington Smyth over the early students of the school that so many high classmen, like Bauerman, the Blanfords, F. Drew, Tookey, Sir C. Le Neve Foster, and many others, went forth to achieve high geological distinction in the world. From Jermyn Street Bauerman proceeded, in 1853, to the Freiberg Mining Academy, whence, after three years further study, he returned to England, and in 1856 accepted the post of an Assistant Geologist on the Geological Survey of Great Britain. But after three years work at home he was selected as geologist to the North American Boundary Commission, and during nearly six years he was occupied in most arduous survey work in Canada and the United States, including the delimitation of the Hudson Bay territory. Between 1863 and 1888 he was busily engaged in Government and professional work, mining and metallurgical surveys, and explorations abroad in almost every part of the world, save Australia and New Zealand. In 1883 he was appointed lecturer on metallurgy at Firth College, Sheffield, and still earlier (1874–9) was joint examiner in mining and mineralogy for the Science and Art Department.

His last official appointment (in 1886) was that of Professor of Metallurgy to the Ordnance College, Woolwich, from which he only retired in 1906, after some twenty years service. As a teacher, Professor Bauerman was particularly successful both with the cadets at Woolwich, who admired and revered him, and with the practical miners and metallurgists, including his workmen-students at the Firth College, Sheffield, and elsewhere, many of whom afterwards became his personal friends.

In addition to important papers read before learned and technical societies Professor Bauerman was the author of textbooks on *Descriptive Mineralogy* and on *Systematic Mineralogy*. But his name is best known perhaps in connexion with his classical work on the *Metallurgy of Iron*, and with the treatise on *Metallurgy* by Phillips & Bauerman. He was for many years a valued contributor to the columns of the *Engineer*, the *Mining Journal*, and other papers.

His extensive knowledge of chemical, mineralogical, and metallurgical subjects, and his experience as a teacher, led to his selection for the office of examiner for many years to the Civil Service Commissioners for the appointment of Mine Inspectors, to the Science and Art Department and the Board of Education in mining and metallurgy, and for a time in mineralogy also. He was likewise examiner of mining students to the Royal School of Mines and the Camborne School of Mines.

Few of the congresses at home or abroad passed without his presence. He was a member of the Metallurgical Committee of the Seventh International Congress of Applied Chemistry held in London this year, and president of a section of the Sixth Congress held in Rome, 1906; and most of our International Exhibitions had the benefit of his experience as counsellor or juryman, from the Great Exhibition in 1851 to the Franco-British in 1908, on whose metallurgical section he wrote two excellent monographs, published by the Iron and Steel Institute.

Mr. Bauerman was elected a Fellow in 1863, and for nearly twenty years served on the Council of the Geological Society (from 1874 to 1898); he also filled the office of Vice-President. He was a most valuable referee on all scientific papers, and, like the late Professor Morris, his knowledge was encyclopædic both of men and subjects.

Bauerman's information was by no means confined to his own particular subjects, but extended over many sciences and arts. His interest in crystallography became an absorbing pursuit; and he found no greater delight than, with no appliances beyond an old envelope, picked out of the waste-paper basket, he would simply by deft folding, accompanied always by constant puffing and blowing, and many a joyful chuckle, develop some extraordinary figure in solid geometry.

Professor Bauerman was a member of many scientific societies both at home and abroad. He was elected an honorary member of the Chemical, the Metallurgical, the Institute of Mining and Metallurgy, and the Iron and Steel Institute. He was an associate member of the Institution of Civil Engineers, as an F.G.S. he for many years filled the office of Treasurer to the Geological Club, and was an associate of the Royal School of Mines. He received the Howard Prize from the Institution of Civil Engineers in 1897, and in 1906 was awarded the gold medal of the Institute of Mining and Metallurgy.

He was a perfect master of three languages, and being of an amiable disposition he always proved a most agreeable and interesting travelling companion, full of keen humour and geniality, so that throughout his life he attracted a large circle of warmly attached and admiring friends.

Professor Bauerman had been seriously ill for about ten weeks, but the immediate cause of his death, which took place peacefully on the morning of December 5, was heart failure. (See notices in the *Engineer*, the *Mining Journal*, *Iron and Steel Institute*, and *Nature*.)

MISCELLANEOUS.

Mr. O. T. Jones, M.A., B.Sc., of the Geological Survey of England and Wales, has been appointed Lecturer in Geology and Physical Geography in University College, Aberystwyth.

Mr. H. J. Seymour, B.A., of the Geological Survey of Ireland, has been appointed Professor of Geology in University College, Dublin.

Museum Destroyed by Fire.—The public library and museum at Kilmarnock has been destroyed by fire. The building, known as the Dick Institute, was presented to the town by the late Mr. James Dick, of Glasgow, about nine years ago. The museum contained the geological collection of the late Mr. James Thompson, F.G.S., the destruction of which is much to be deplored.—*Times* (weekly ed.), December 3, 1909.

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FEBRUARY, 1910.

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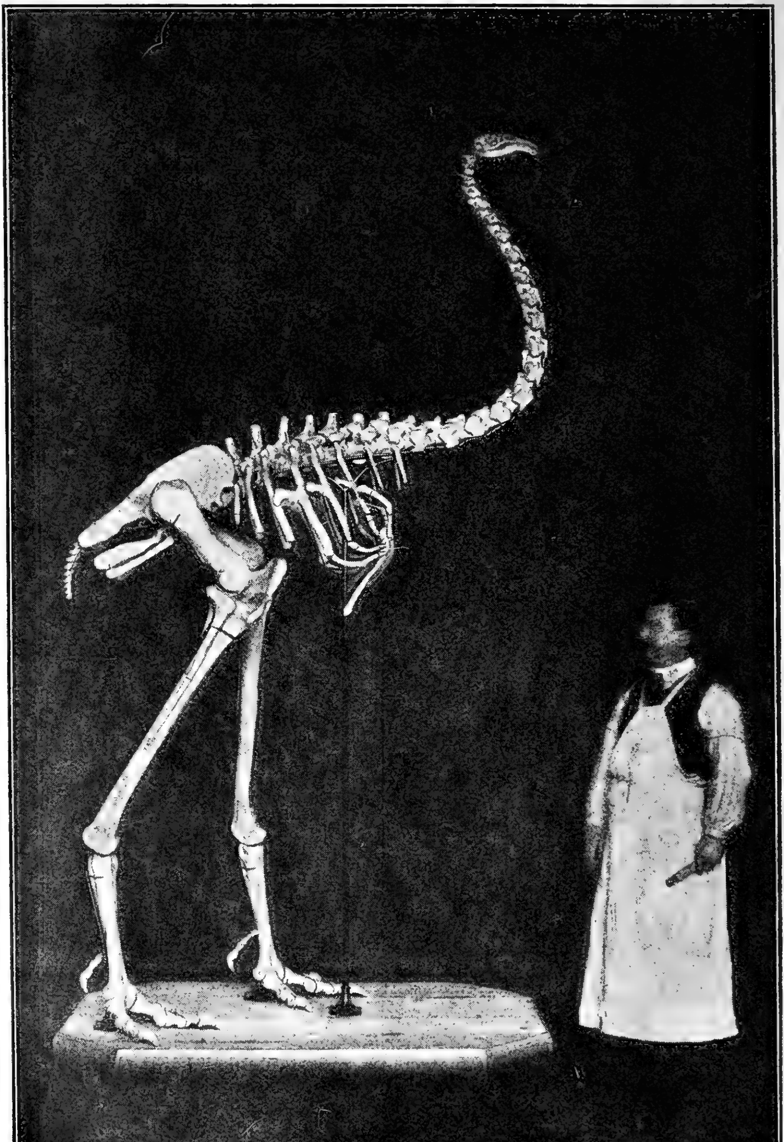
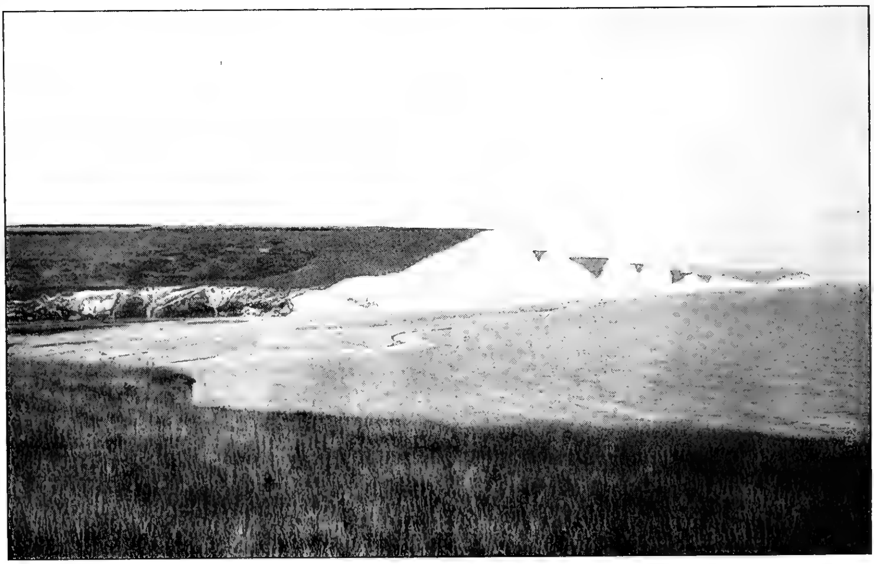


A COMPLETE REPRODUCTION OF THE SKELETON OF
DINORNIS MAXIMUS
(the gigantic 'Moa' of New Zealand) as supplied to the Natural History Museum, Brussels, by
ROBERT F. DAMON, Weymouth, England.
Height 300 cm.

1



2

The Sculpturings of the Chalk Downs.

Fig. 1. Simple coombes near Ditchling Beacon, Sussex.
Fig. 2. The 'Seven Sisters', between Cuckmere Haven and Birling Gap, Sussex.

THE

GEOLOGICAL MAGAZINE.

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No. II.—FEBRUARY, 1910.

ORIGINAL ARTICLES.

I.—The Sculpturings of the Chalk Downs of Kent, Surrey, and Sussex.[1] By George Clinch, F.G.S., F.S.A. Scot.

(PLATE VI.)

THE aim of this paper is to offer an explanation of the phenomena intimately related to the sculpturings of the Chalk Downs in the district under review, namely :—

(1) The Dry Chalk Valleys.
(2) The River System of the Wealden area, as far as it relates to the Chalk Downs.
(3) Incidentally, the Denudation of the Wealden area.

The various sculpturings of the Chalk Downs fall naturally into two main groups, viz. :—

(1) Dry Valleys, comprising—
  (*a*) Simple coombes, or short valleys, without tributary valleys, and
  (*b*) Complicated, sinuous valleys, usually extending for some miles, and with numerous tributary valleys.
(2) Wet Valleys, cut through the North and South Downs, in which flow rivers which drain the Wealden area.

The chief characteristics of the Dry Valleys (1) are steep, sloping sides, rounded outlines, absence of terraces, general absence of deposits of flints, etc., and proportionately large area of valley as compared with unsculptured areas.

The simple coombes or short valleys (*a*) are found usually on the Chalk escarpment opposite the Weald, and are remarkable for their steepness, both of sides and the general fall of the level of their deepest parts. (See Pl. VI, Fig. 1.)

The complicated, sinuous valleys (*b*) are found usually on the northern slope of the North Downs and the southern slope of the South Downs. The number of tributaries and the breadth of the valleys are two remarkable features to which no one yet seems to have drawn particular attention. They are points which certainly do not appear to have been sufficiently explained by the theories hitherto advanced by geologists. If at first they seem to present difficulties, these very difficulties are of the greatest value as indicating

[1] This paper is substantially the same as that communicated to the Geological Society of London, April 7, 1909, certain revisions having been made subsequently. A short abstract only was printed in the Q.J.G.S., vol. lxv, pp. 208–9.

the direction in which we may look for an explanation of the whole story of the origin and development of the valleys of the Chalk Downs.

Excellent examples of valleys of this type are to be found in abundance in the North and South Downs, in the former especially to the south of Croydon, in West Kent, and throughout the eastern portion of Surrey. (See Fig. 1.)

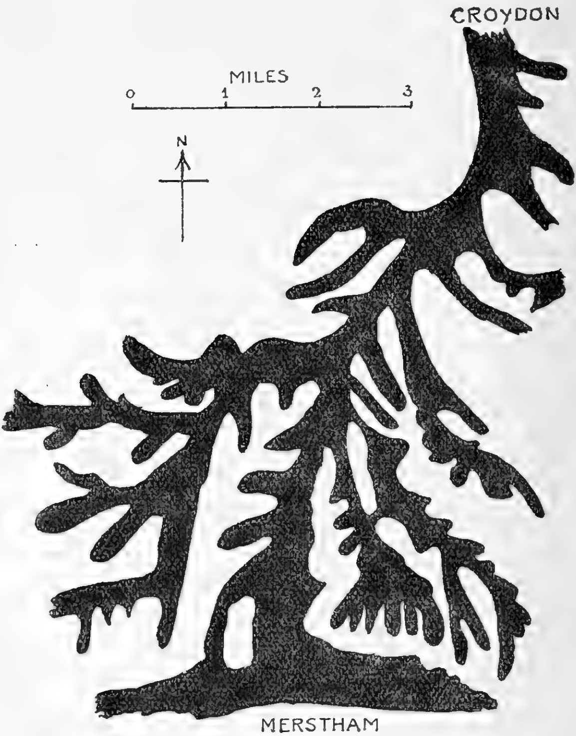


Fig. 1. Diagram showing complicated and sinuous Dry Chalk Valleys of the North Downs between Merstham and Croydon, Surrey.

The Wet Valleys (2) are characterized by the large size and breadth of their passages through the Downs, and by the extensive watersheds drained by the rivers which now occupy them. In general outline and character they are not unlike the Dry Valleys, but they are invariably cut to a lower level in the Chalk, and in all cases, I think, they contain deposits of river gravel. Generally speaking, however, they are of less complicated form than the Dry Valleys. The following rivers now occupy the Wet Valleys of the district with which the present paper is concerned: (*North Downs*) Wey, Mole, Darent, Medway, Stour; and (*South Downs*) Cuckmere, Ouse, Shoreham River or Adur, and Arun.

The neighbourhood of Beachy Head presents many interesting points which illustrate the sculpturing of the Chalk Downs. The Chalk here ends abruptly in a lofty cliff, which once extended much farther to the south. The western slopes of the Downs in this part of Sussex are somewhat precipitous and form part of the watershed of the River Cuckmere, an important watercourse whose most distant source may be traced to Heathfield Park. The river has several tributaries, and drains a large part of the Sussex Weald. Its former importance is indicated much more vividly by the valley through which it flows than by the present volume of its waters.

Between Cuckmere Haven and Birling Gap the sea-coast presents a remarkable series of gable-like cliffs, known, from the number of its eminences, as the Seven Sisters (see Pl. VI, Fig. 2). These elevated points of Downland are divided by eight valleys leading in a practically north and south direction, but six of them are short and of simple form, dying out about a mile to the north of the sea-coast. The others are of more complicated form. It is clear that they all form parts of a complete system of branching valleys, which formerly drained the district. All the southern part has been eroded by the sea, and what may be called the midrib of the series was situated

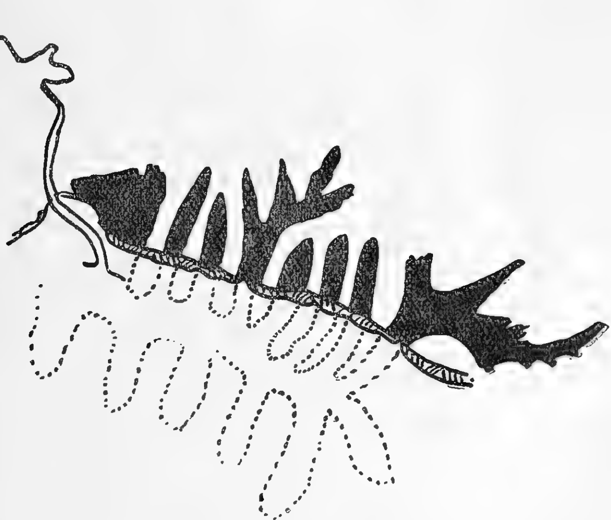


Fig. 2. Diagram showing the Dry Chalk Valleys of the 'Seven Sisters', and a suggested restoration of the valley system in the neighbourhood.

perhaps within 2 miles of the present coastline (see Fig. 2). The destruction of this series of dry valleys was probably due partly to marine erosion and partly to the forces which excavated the valley through which the Cuckmere River now flows. The nature of those forces will be considered at a later stage in the paper.[1]

[1] See a paper "On the Geology of the Neighbourhood of Seaford", by J. V. Elsden: Q.J.G.S., vol. lxv, pp. 442–61.

Deposits in the Dry Valleys.

Generally speaking the Dry Chalk Valleys do not contain any considerable amount of deposits of hard and insoluble matter. Many are indeed quite free from such accumulations; but some are partially occupied by beds of re-arranged Chalk; chalky matter interspersed with sand from the Wealden beds; flints, worn and unworn; ferruginous sandstone from the Lower Greensand; and masses of Sarsen Stone.

An important and significant deposit occupies the bottom of the valley at Purley, near Croydon, a valley which, although now dry, once formed the upper part of the Wandle Valley (Fig. 1) when that river drained part of the Weald. It contains blocks of Sarsen Stone of large size, weighing about a ton, large blocks of equal weight of pebbly conglomerate, and numerous subangular flints as well as Tertiary pebbles. A good section of this was exposed when the waterworks at Purley were constructed. Sarsen blocks of smaller size, and chalky material and flints occur in the Coombe Rock at Black Rock near Brighton.

Denudation of the Weald.

The relation of Chalk sculpturings to the denudation of the Weald was probably intimate. Strictly considered, it is clear that the very sculpturings with which this paper deals are but part of the process of the uncovering of the Wealden strata, by the erosion of the Chalk and other superincumbent deposits. Nevertheless the paucity of remains of the harder and more insoluble parts of the Chalk in the Wealden area is well known, and this circumstance has given rise to an extraordinary variation of opinions amongst geologists as to the force or forces which have removed the Chalk. The elevation of the centre of the Weald is another important point, and unquestionably it has had much to do with this denudation. How far the actual upheaval may have broken up the Chalk cannot now be estimated with precision. There can be no doubt that there was much dislocation and disruption, although the views expressed by some writers[1] on the subject seem to be extravagant.

The Wet Valleys which cut through the Downs are probably the channels by which the eroding and transporting forces conveyed the material to other areas outside the Weald. What those forces in all probability were is a question upon which I shall have occasion to touch when dealing with the origin of the dry valleys; but, I may add, I do not for a moment suggest that anything of the nature of glaciers was the transporting force.

Relation of Dry Chalk Valleys to Clay-with-Flints.

The origin of Clay-with-flints on the higher Chalk has long been a disputed point. Geologists are by no means agreed as to whether

[1] In *Scepticism in Geology* (pp. 44–5), William Longman suggested that "the Chalk escarpments may have been parted asunder like the sinews of a shoulder of mutton on the application of a knife"; and Sir Henry Howorth in *Ice or Water*, vol. i, p. 525, holds that the Chalk beds were dragged apart over the softer underlying strata for a distance of 25 miles. To my mind such an extended movement of the Chalk seems unlikely.

it is a mechanical or a chemical deposit; but, I think, the study of its phenomena in connexion with the dry valleys of the Chalk tends to show that it was due to mechanical rather than chemical agencies. It lies mainly on the table-lands of the Chalk, and is rarely found in the valleys except in a re-arranged condition or as rainwash.

The extreme probability that its material was derived in the first instance from the dissolution of the Chalk does not, I submit, militate against the possibility of its subsequent re-arrangement by mechanical agencies.

The presence of clay-with-flints on the Chalk plateau and its absence from the valleys are points well shown in Kent. A good example to the east of the River Darent has been figured in one of the admirable papers of the late Sir Joseph Prestwich.[1]

River Systems.

It will not be necessary, for the present purpose, to go deeply or fully into the river system of the Weald; but the fact that many of them flow through channels which cut transversely through the Chalk Downs, both north and south, is important as pointing to a very early system of watercourses which drained not only the Wealden area as we know it, but the Wealden dome before it was bereft of its Chalk and Tertiary beds.

The valleys of the Wye, the Mole, the Medway, the Cuckmere, the Ouse, the Shoreham River (now called the Adur), and the Arun are broad and important. The Darent Valley is less marked. That of the Wandle is well-defined, but dry in its upper part, having had its catchment area cut off by the rapid development of the Gault valley. The old valley of the Ravensbourne, the main part of which is now dry, goes quite as far south as the Chalk escarpment, and probably once drained a small part of the Wealden dome. The chief point of interest of all these valleys is that they run transversely to the lines of the Chalk ridges, and point to an ancient drainage system.

The fact that the gravels in these valleys contain materials brought from the Wealden side of the Chalk escarpment is another of the interesting points in their geological history.

Theories on the Denudation of the Weald and the Formation of Valleys.

The papers "On the Anticlinal Line of the London and Hampshire Basins", by Peter John Martin, F.G.S., are of great value. They are, in fact, a storehouse of information to which Lyell and many subsequent writers have turned for inspiration and facts. Martin's papers were published in the *Philosophical Magazine* in 1851, 1854, and 1857, but they deal with observations made as early as 1828. After discussing the various phenomena of the Weald, he writes:—

"To conclude: the obvious inferences to be drawn from what we have seen are these:—

"Since the deposition of the tertiary beds a great and sudden upheaval of some parts, and perhaps contemporaneous subsidence of others, took place over a widely extended area; perhaps over the greater part of the South of England.

[1] Q.J.G.S., vol. xlvii, pl. vii. See also Jukes-Browne, ibid., vol. lxii, p. 132.

"That the phenomena of the arrangement of valleys, and of watersheds, over all the length and breadth of the anticlinal line of the London and Hampshire basins, respond to this covvulsion.

"That this convulsion was attended or immediately followed by a devastating flood, which excavated and carried off the broken materials, and only left a small quantity of drift to attest its agency; and that this inundation subsiding, the waters withdrew at once, a period of tranquillity succeeding, which has continued up to the present time."

Mr. Clement Reid's paper,[1] "On the Origin of Dry Chalk Valleys and of Coombe Rock," was published twenty-two years ago, and I think all geologists will admit the value of his contribution to the subject of Chalk hill-sculpture.

Mr. Reid commenced his paper by pointing out the intimate relation of Dry Chalk Valleys and Coombe Rock, a position which I suppose no one would now wish to challenge. After a description of the seaward side of the South Downs, and of the general features of Dry Chalk Valleys, the author proceeded to discuss the various theories advanced by geologists to account for the erosion of the Dry Valleys. He cited three theories, viz.:—

(1) Former submergence, and consequent rise in the plane of saturation.
(2) A former higher level in the plane of saturation before the valleys had been cut to their present depth.
(3) An enormous increase in the rainfall.

All these theories were dismissed as insufficient to account for the phenomena of the Dry Valleys, although their partial aid in producing them was accepted. Mr. Reid remarks: "If these valleys had been gradually cut back by streams, many of them ought to fall northward to the escarpment, where most of the large springs are found; but nearly all the Chalk Coombes follow the general slope of the ground and open to the south."

The most important part of Mr. Reid's paper is that in which he deals with the question of the origin and method of erosion of the valleys. Judging from the flora and fauna, he assumes that the temperature of North-West Europe, at the period under review, was probably 30° lower than it is now. He writes:—

"This would give a mean temperature in the South of England very considerably below the freezing-point; consequently all rocks not protected by snow would be permanently frozen to a depth of several hundred feet. This would modify the entire system of drainage of the country in a way that I do not think has been realized. All rocks would be equally and entirely impervious to water, and all springs would fail. Whilst these conditions lasted any rain falling in the summer would be unable to penetrate more than a few inches. Instead of sinking into the Chalk, or other pervious rock, and being slowly given out in springs, the whole rainfall would immediately run off any steep slopes like those of the Downs, and form violent and transitory mountain-torrents. These would tear up a layer of rubble previously loosened by the frost and unprotected by vegetation. The material carried away would not have the Chalk washed or dissolved out, for a single flood of this description could have little solvent power, and much of the Chalk might not be thoroughly thawed.

"Each of these floods would have an enormous scouring and transporting power; for the fall in the valleys is very great. It is noticeable that no Coombe Rock is found in the valleys that have a greater slope than 100 feet to the mile, and that the main mass is deposited south of the Downs where the slope is much less."

[1] Q.J.G.S., vol. xliii, pp. 364–73.

In the discussion to which Mr. Reid's paper gave rise, the most remarkable view on the subject was expressed by Professor Seeley, who attributed the Dry Valleys mainly to marine erosion. He suggested, too, that the deposit of Clay-with-flints had been swept into its present position by 'tidal waves' at the time when the land was being submerged and the waters were working up the valleys.

Sir A. Geikie remarked that the valleys were doubtless outlined before the Chalk was exposed at the surface, and then subsequent erosion in the Chalk had been effected by solution and mechanical abrasion under conditions which have now disappeared.

Topley referred the origin of Dry Chalk Valleys to the action of 'running water' on land that was solidly frozen.

It will be observed that several authorities were inclined to ascribe the origin of the valleys to the erosion of running water. Seeley's theory as to marine action may be dismissed, perhaps, as lacking both proof and probability, but Topley's suggestions as to 'running water', and Mr. Reid's as to summer floods, are, I venture to think, scarcely less inapplicable.

If water, even in the form of 'mountain-torrents', as Mr. Reid suggests, was the excavating force, we should expect to find (1) a sufficient watershed, (2) terraces on the sides of the valley representing different stages in the volume and velocity of the torrent, and (3) a deposit of hard and insoluble matter, such as flints and other debris of the Chalk. The first and second of these features are lacking, and the third is by no means constant.

Since the publication of Mr. Reid's paper geologists have sought in other directions for explanations of the Dry Chalk Valley systems. One of the theories most in fashion in recent times is that known as the 'solution' theory, by which pluvial activity is invoked, and the whole of the phenomena of Chalk sculpturings is by some referred to the solvent influence of rain and atmosphere.[1]

The direction of the Dry Valleys, we are told, was determined by the courses of streams and rivers on the surface of the Chalk plateau in remote times. The effect was to remove the clay capping and thus lay bare the soluble Chalk to the influences of rain and atmosphere. Every part which was bereft of its clay protection became in time, after a long series of years, hollowed out into valleys.

I am bound to say that this theory, ingenious as it is, gives, to my mind, far too great importance to (1) the solubility of the Chalk, and (2) the influence of rainfall. Indeed, I think such a theory is insufficient to account for certain definite and fairly constant characteristics of these sculptured channels, the most important and obvious of which are (1) the sinuosities of the valleys, (2) their elaborate and complicated forms, (3) the general downward inclination of the valleys towards their outlets, and (4) the presence of rolled chalk, flints, etc., in the valleys themselves.

That erosion rather than solution was the active force in the formation of some of the dry chalk valleys is shown by deposits of high-level gravels having been cut through. Now, it is obvious

[1] See G. W. Young, Proc. Geol. Assoc., 1905, vol. xix, p. 191.

that if the valley were due to solution the gravel would have been let down with the lowering surface of the chalk, but the fact that it has been entirely swept out of the valley affords clear proof of erosion. There is abundant evidence of this, but for the present purpose it will suffice if reference is made to the excellent example in the Seaford district to which Mr. J. V. Elsden has recently drawn attention in his paper,[1] already mentioned, on the geology of that neighbourhood.

That a certain amount of sculpturing of the Chalk may be attributed to solution, either pluvial, or atmospheric, or both, particularly in association with joints or faults, is well known and indisputable. An excellent example may be seen at Box Hill, near Dorking, in Surrey, and there are many others. But in these the bottom of the depression is not regularly inclined downwards, like those of the typical Dry Valleys.

Moreover, the solution theory leaves us much in want of some reasonable controlling force which, in the initial and early stages, would give form to the complete and elaborate valley system. If the solution theory were accepted we should expect deep ravines in the Chalk, following precisely or nearly the direction of the original stream or river which removed the clay capping. A certain broadening would doubtless follow in the course of time, but we should not expect such elaboration and development as we actually find. The erosion would be in the direction of depth rather than breadth, because the degraded clay on the sides of the valleys would still continue, to some extent, to protect the Chalk from rainfall and consequent solution. In a word, the solution theory involves vertical rather than lateral development, yet lateral development is one of the most noteworthy characteristics of the valleys.

Another weak point, among many, about the solution theory is that it fails to account for Dry Valleys on the Chalk escarpment, where there is no controlling and protecting clay covering.

Finally, I submit, the solution theory is effectually disproved by the rolled material in the valleys.

Mr. Reid's suggestion that upon the approach of mild temperature floods like mountain-torrents swept the loosened material out of the Chalk valleys, makes no sufficient allowance, I think, for the vast masses of ice which, wholly or in part, must have occupied the valleys. The presence of these ice-masses must have tended to lateral erosion and consequent widening of the valleys.

The porous nature of Chalk is a point with which Mr. Reid deals thoroughly, and I think his theory that the bed was rendered impervious by means of frost is one which has generally been accepted by geologists. But I do not think it at all likely that the frost extended downwards into the earth for some hundreds of feet, because there would doubtless be a protecting covering of snow. Ten or twenty feet would be ample to render the Chalk impervious, and I cannot find evidence of frost at a greater depth.

Those who have hitherto attempted to explain the denudation of the Weald and the formation of the Dry and Wet Valleys of the Chalk

[1] Q.J.G.S., vol. lxv, pp. 442–61.

Downs as due to the erosive action of water, have not, I think, given sufficient importance to the fact that Chalk, of all rocks, is peculiarly sensitive to the disintegrating influence of frost, particularly when the beds are heavily charged with water. The effects of a frost may be seen, when thaw sets in, in every chalk-cutting and chalk-pit. What its effects may have been when these valleys were half-filled with water and the temperature fell very low, it is difficult to realize at the present time; but the work that was accomplished by alternate freezing and thawing is to be seen in the valleys of the Chalk Downs, many of which are eaten back by the disintegrating and disrupting frost into intricate and complicated forms. In some cases this erosion has been carried to the extent of breaking down the divisions between adjacent valleys, and the formation of isolated hills. (See Fig. 1.)

The suggestion I make, then, is that the chief eroding agent was, not the waves and tides of the sea as some have suggested, nor the 'running water', nor the 'mountain-torrents' of others, but the frost itself acting upon Chalk charged or saturated with water.[1]

By this means, I suggest, the valleys were cut back into the Chalk Downs, the development being to a large extent lateral. The frost was most active, I suggest, where the Chalk was wettest, and the waters standing in the valleys half-choked with ice provided precisely the necessary condition to produce the maximum breaking-up of the Chalk.

I have spoken of the relatively small size of the catchment-area as compared with that of the valleys. It had, to me, long been an enigma; but with the explanation I offer, I think, the difficulty disappears, because the eroding forces were contained in the valleys themselves when the Chalk below was impervious and they were partly filled with water. The wet condition of the Chalk may have arisen from partial thaw and not wholly from rainfall.

At the same time it must be borne in mind that the condition of semi-saturation, under which the frosts were most destructive to the Chalk, was most naturally produced when there was some kind of catchment basin. Indeed, it would seem that such a basin was absolutely necessary to produce the requisite conditions, because when the valley was cut back quite near the edge of the Chalk escarpment, and the drainage became insignificant, the hollow channel dies out.

The transporting agencies of floating ice, and the floods arising from the periodical breaking-up of the ice-masses in the valleys would doubtless be sufficient, in the case of the steeper valleys or coombes, to sweep the debris down into the sea or into the valley or estuary of the Thames.

The whole of the phenomena of the Dry Chalk Valleys and other forms of sculpturings of the Chalk Downs may, I submit, be amply accounted for by the forces I have attempted to describe; and if, as seems obvious, the valleys be closely related to the denudation of the Weald, it is perhaps within the region of probability that the latter may have been influenced by the same cause.

[1] On this subject see remarks by S. V. Wood, jun., Q.J.G.S., vol. xxxviii, p. 718.

EXPLANATION OF PLATE VI.

FIG. 1. This photograph of the northern escarpment of the South Downs near Ditchling Beacon affords an admirable illustration of the simple steep coombes to which reference is made in the paper. Ditchling Beacon is shown on the high point about the middle of the view. At the foot of the steep escarpment is shown the ancient hedge which separates the down land from the arable land of the Weald. The latter in prehistoric and early historic times was largely forest land.

,, 2. The Seven Sisters, a series of alternate valleys and lofty cliffs, owe their shapes to a former system of branching dry valleys, much of which has been destroyed, probably by marine erosion.

II.—NOTES ON THE FOSSIL FLORA OF THE BRISTOL COAL-FIELD.

By D. G. LILLIE, B.A., St. John's College, Cambridge.

(PLATE VII.)

MORE than twenty-three years have now passed since Dr. Kidston published his memoir on the fossil flora of the Somerset and Bristol Coal-field, and in the meanwhile no further additions to our knowledge have been made. Kidston's paper was chiefly concerned with the plant-remains of the southern or Radstock portion of the basin. Those from the northern or Bristol area have only been studied incidentally. This would seem quite natural on account of the greater size and industrial importance of the Radstock Coal Series, and from the fact that this locality has been long known to yield the finest and best preserved impressions of fossil plants to be found in any coal-field in the British Isles. The collieries in the Bristol district are comparatively few and smaller, fossil plants being much scarcer and less well preserved.

In view of the fact that the Bristol area is becoming less extensively worked every year, it has seemed to me worth while to collect as many plants as possible from this district, in the hope of adding to those already recorded. It also has been desired to obtain a flora sufficiently characteristic to indicate the palæobotanical horizon as compared with those of the Radstock district and other coal-fields. At present the evidence rests entirely on stratigraphical data. With this end in view, I spent some weeks, during the last two summers, in collecting fossil plants from the waste-heaps of the seven collieries which alone appeared to be still working in the Bristol district.

In recent times several collieries have been completely abandoned, including all those on the Nailsea basin, and the possibility of obtaining plant-remains from this coal-field is becoming less every year. The spoil-heaps of four of the collieries now working proved to be almost completely barren on both occasions when I visited them, the shale being much slickensided and all organic remains obliterated. Thus there remained only three collieries from which plants can be collected, and one of these is exceedingly small. A week's work was consequently sufficient each year to practically exhaust the spoil-heaps.

The physical features and stratigraphy of the Bristol district have been described by several writers[1] in the past. In more recent

[1] See Kidston, Trans. Roy. Soc. Edinb., vol. xxxiii, pt. ii, p. 338 note.

years, important and able papers by Mr. James McMurtrie, F.G.S.,[1] and Mr. H. Bolton, F.G.S.,[2] have been added to this list. It will only be necessary to very briefly recapitulate the main characters of the area for the purposes of the present paper.

The Coal-measures of the Somerset and Bristol basin consist of two productive divisions, separated by the Pennant Rock. The upper division, lying above the Pennant, is again divisible into a higher, the Radstock Series, and a lower, the Farrington Series, separated by barren beds known as the Red Shales. The lower division can be also subdivided into the New Rock and Vobster Series, though the line of demarcation between them is less distinct. The succession of the Coal-measures in that part of the basin which intervenes between the Radstock district and the neighbourhood of Bristol is not known with certainty; but the main stratigraphical divisions of the latter appear to correspond with those at Radstock, though it has not been found possible to correlate the coal-seams of the two areas. Indeed, the correlation of many of the seams, even within the Bristol area itself, are either unknown or uncertain.

The following table indicates a comparison of the series in the two districts, and includes the names of the collieries at present working in the Bristol area :—

Radstock Area.		Collieries in the Bristol Area.
Upper Division (2200 feet)	Radstock Series (about eight seams).	Absent.
	Red Shales.	Very thin.
	Farrington Series (six or more seams).	Coal Pit Heath Colliery. Working same seams { Parkfield Colliery. Shortwood Colliery.
Pennant Rock (3000 feet).		
Lower Division (2800 feet)	New Rock Series (eighteen or more thin seams).	Working same seams { Kingswood Collieries (Speedwell Pit, Deep Pit), Easton Colliery.
	Vobster Series (eight or more seams).	Hanham Colliery (?).

We thus see that there are now only three collieries at work in the Farrington Series in the Bristol district. Each, however, is working several seams, and all three have yielded fossil plants; but the exact seam from which they came is unknown. Coal Pit Heath Colliery is probably working higher seams in the Farrington Series than Parkfield and Shortwood Collieries. Two collieries are working, three pits in all, in the New Rock Series, but only one specimen could be obtained from the heaps after repeated searching. The Hanham Colliery, which, it is believed, is working the Vobster Series, has also proved entirely barren as a collecting-ground.

Thus the impressions described here are all derived from the Farrington Series, and these may be compared with the flora of the same series in the Radstock area, already described by Kidston.[3]

So far we have been concerned only with the impressions, but some

[1] McMurtrie, Trans. Inst. Mining Engineers, 1901, vol. xx.
[2] Bolton, Q.J.G.S., 1907, vol. lxiii, p. 445.
[3] Kidston, Trans. Roy. Soc. Edinb., vol. xxxiii, pt. ii, p. 410.

interesting plant petrifactions have also been obtained, and we may commence with a brief notice of these.

PETRIFACTIONS.

In addition to impressions found in the shale bordering on the coal-seams, a limited amount of petrified material has also been obtained, which is of special interest, because our supply of structure material has hitherto been confined to one or two seams in the Lower Coal-measures of Yorkshire and Lancashire. This material was originally recognized by Mr. Bolton, F.G.S., Curator of the Bristol Museum, who drew my attention to it. It has only been obtained at one locality, Staple Hill, about 3 miles to the north-east of Bristol, on the north side of the Kingswood anticline. A sinking was made here a year or two ago, through the Pennant Grit, but was afterwards abandoned at a point rather beyond the base of the Pennant. At this level a peculiar breccia-conglomerate, containing numerous angular and rounded pebbles, set in a sandstone matrix, was met with in sinking the shaft. This rock will be more fully described by Mr. Bolton. It is only necessary here to add that, in addition to the pebbles, this breccia contains numerous fragments of stems and petioles of plants in some of which the structure is preserved; the material being calcified. The amount of this conglomerate is very limited, and it is very doubtful whether any more can be obtained in the future. Many of the blocks thrown out from the shaft have become considerably weathered, and the plant petrifactions quite spoilt for purposes of section cutting. However, a number of sections have been cut of the petrified material, and several of these proved to be well-preserved stems or petioles. Twigs of *Cordaites* appear to be the commonest fossils, while in addition a well-preserved petiole of *Myeloxylon* has been obtained. It is hoped that an opportunity will be found to describe these structure specimens before very long. At present we must content ourselves with a record of their discovery.

IMPRESSIONS.

We now pass to a record of the plant impressions obtained from the Farrington Series in the Bristol district.

The following list of plants, recorded by Dr. Kidston in 1887, comprised the entire flora then known from the Farrington Series of this area, and no further additions have been made, as far as I am aware, up to the time of writing:—

	Localities.		
EQUISETALES.	Coal Pit Heath.	Parkfield.	Puckle-church.
Calamites ramosus (Artis)	—	x	
Annularia stellata (Schloth.)	—	x	
SPHENOPHYLLALES.			
Sphenophyllum emarginatum, Brongn.	—	x	—
PTERIDOSPERMS AND FERNS.			
Alethopteris lonchitica (Schloth.)	—	x	—
Neuropteris macrophylla, Brongn.	—	x	—
N. ovata, Hoffman	—	x	—
Pecopteris arborescens (Schloth.)	—	x	x

	Localities.		
Pteridosperms and Ferns (*continued*).	Coal Pit Heath.	Parkfield.	Puckle-church.
Pecopteris oreopteridia (Schloth.)	–	x	–
P. pteroides, Brongn.	–	x	–
Rhacophyllum crispum, Gutbier	–	x (?)	–
R. Goldenbergi, Weiss	–	–	x
Caulopteris macrodiscus, Brongn.	x	–	–
Lycopodiales.			
Sigillaria reniformis, Brongn.	x	–	–
S. Voltzia, Brongn.	x	–	–
S. elongata, Brongn.	–	x	–
Stigmaria ficoides, Sternb.	–	x	–

We now proceed to record the additions which we have been able to make to this flora:—

Equisetales.	Locality.
Calamites Suckowi, Brongn.	Parkfield Colliery.
C. Cisti, Brongn.	Parkfield Colliery.
Calamites sp. (external surface)	Parkfield Colliery.
Annularia sphenophylloides (Zenker)	Coal Pit Heath Colliery. Parkfield Colliery. Shortwood Colliery.
Annularia cf. *radiata* (?), Brongn.	Coal Pit Heath Colliery.
Pteridosperms and Ferns.	
Sphenopteris neuropteroides (Boulay)	Coal Pit Heath Colliery. Parkfield Colliery.
S. ovatifolia, sp. nov.	Coal Pit Heath Colliery. Shortwood Colliery.
Alethopteris Serli (Brongn.)	Shortwood Colliery.
Neuropteris flexuosa, Brongn.	Parkfield Colliery.
N. Scheuchzeri, Hoffm.	Coal Pit Heath Colliery.
Pecopteris polymorpha, Brongn.	Coal Pit Heath Colliery.
P. crenulata, Brongn.	Coal Pit Heath Colliery.
P. Miltoni (Artis)	Coal Pit Heath Colliery. Parkfield Colliery. Shortwood Colliery.
Pecopteris (*Dactylotheca*) *plumosa* (Artis)	Shortwood Colliery.
Mariopteris muricata (Schloth.)	Coal Pit Heath Colliery.
Macrosphenopteris (?) sp.	Parkfield Colliery.
Trigonocarpus Noeggerathi (Sternb.)	Coal Pit Heath Colliery. Parkfield Colliery.
Trigonocarpus sp. (outer surface)	Coal Pit Heath Colliery.
Rhacophyllum spinosum, Lesqx.	Parkfield Colliery.
Schizopteris lactuca, Presl	Coal Pit Heath Colliery.
Lycopodiales.	
Lepidodendron lanceolatum, Lesqx.	Coal Pit Heath Colliery. Shortwood Colliery.
Lepidodendron cf. *L. Glincanum*, Eichw.	Parkfield Colliery.
Lepidophyllum majus, Brongn.	Coal Pit Heath Colliery.
Cordaitales.	
Cordaites angulosostriatus, Grand'Eury	Coal Pit Heath Colliery.

Descriptions of the Specimens.

Two of the determinations above mentioned have not hitherto been recorded from Britain. One of these appears to be a new species of *Sphenopteris*, the other a species of *Lepidodendron*, new to Britain.

SPHENOPTERIS OVATIFOLIA, sp. nov. (Pl. VII, Figs. 4 and 5; Text-figs. 1–3.)

Description.—Smaller ultimate pinnæ, alternate, 15 mm. long, narrow, deltoid in shape. Pinnules ovate or ovate-lanceolate, delicate, 4–5 mm. in length, 2–2·5 mm. broad, confluent above but separate and contracted at the base below, entire when small or lobed when larger, margin slightly sinuate or (?) toothed. Terminal pinnule not seen. Veins distinct, median nerve not extending to apex, lateral nerve single, or once, or more rarely twice, forked, in which case the branches fork widely. Nervation of the *Renaultia* type. (Pl. VII, Fig. 4; Text-fig. 1.) Larger pinnæ, more than 2·5 cm. long. Pinnules ovate-lanceolate, contracted at base, 5–6·5 mm. long with six to eight or more lobes. (Pl. VII, Fig. 5; Text-figs. 2 and 3.) Pinnules sometimes overlapping.[1]

The same species or very closely similar specimens have been collected by Mr. Arber from Kilmersden Colliery, Radstock.[2]

FIG. 1. *Sphenopteris ovatifolia*, sp. nov. Enlarged pinnules to show the nervation. × 4 times nat.

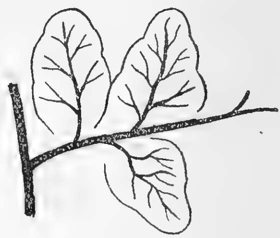


FIG. 2. *Sphenopteris ovatifolia*, sp. nov. Enlarged pinnules to show the nervation. × 4 times nat.

FIG. 3. *Sphenopteris ovatifolia*, sp. nov. Enlarged pinnules showing the nervation. × 4 times nat.

Affinities.—*Sphenopteris ovatifolia*, sp. nov., differs from *Renaultia Footneri* (Marratt) in the pinnules being much larger, in the rachis not being winged, and in the shape of the pinnules. *Renaultia chærophylloides* (Brongn.) was at first thought to be the species to which these specimens belonged; but it is really quite distinct. The

[1] Nos. 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, Carb. Plant Coll. Sedgwick Mus., Cambridge.

[2] Nos. 1703, 1704, 1705, 1549, in the same collection.

pinnules of *R. chærophylloides* are more sinuate and much less contracted at the base than in our specimens. *R. schatzlarensis* (Stur) is less like these specimens than *R. chærophylloides.* The pinnules of this species are much more deeply lobed than in our specimens, giving the appearance of a much less massive frond, whereas *S. ovatifolia* is less massive than *R. chærophylloides.*

LEPIDODENDRON cf. L. GLINCANUM, Eichwald.[1] (Pl. VII, Figs. 1–3; Text-figs. 4 and 5.)

Description.—Impressions of stems, 15 × 5 cm., showing two states of preservation. The more external impression is probably the external surface very slightly decorticated (as seen at *a* in Figs. 1 and 3, Pl. VII, and in Text-fig. 4). The leaf-bases are small, very elongate, fusiform in shape, each leaf-base being joined to the one above and below by a narrow ridge. Taking the middle points of these ridges as the limits of the individual leaf-bases, each leaf-base is 1·4 cm. long by 1 mm. broad across the greatest width. The cushion is 6 mm. long. The lateral angles are rounded. The leaf-scar is not preserved. There is no ridge, or only a slight indication of a ridge, on the cushion. There is a well-marked narrow ridge between each cushion, which is continuous with the prolongations of the cushions above and below as mentioned above.

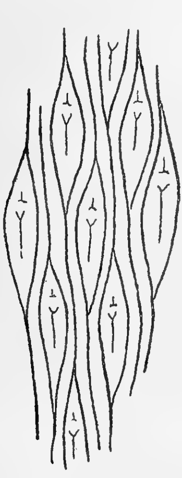


FIG. 4. *Lepidodendron* cf. *L. Glincanum*, Eichw. More external surface. × 3.

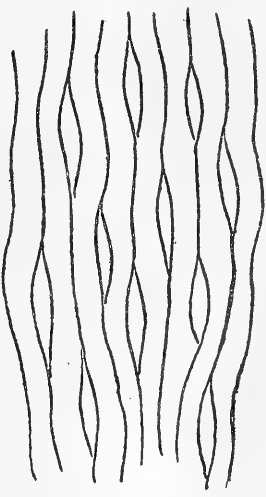


FIG. 5. *Lepidodendron* cf. *L. Glincanum*, Eichw. More decorticated surface. × 3.

The more decorticated surface (seen at *b* in Pl. VII, Figs. 1 and 3, and Text-fig. 5), shows shorter fusiform areas between well-marked flat-topped bands 1 mm. in width.

Attribution of the Specimens.—Though these specimens are not ill preserved, yet they do not show the leaf-scar. Consequently they

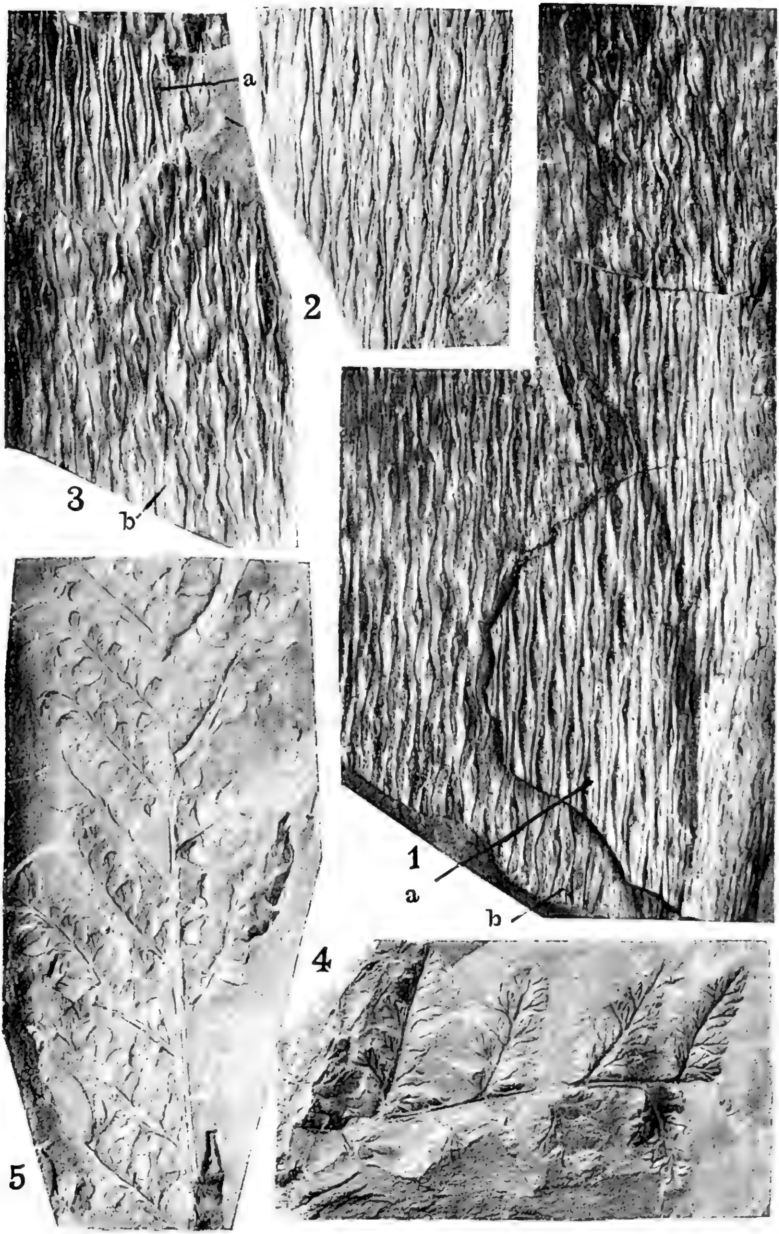
[1] Nos. 2068, 2080, 2081, Carb. Plant Coll. Sedgwick Mus., Cambridge.

cannot be identified specifically. The nearest species appears to be *Lepidodendron Glincanum*, Eichwald, especially the figure on pl. v (*a*), fig. 5 of that author's *Lethæa Rossica*.[1] Also another specimen attributed to this species by Dr. Kidston (pl. v, figs. 41–3),[2] bears a marked resemblance to this fossil. We may, however, first discuss some other species with which comparison may be made. The first of these is *Lepidodendron rimosum*, Sternberg, to which Zalessky[3] attributes Dr. Kidston's figures above mentioned. In the true *L. rimosum* the leaf-bases are much larger, more widely separated by striated bark, while in older stems of the same plant the separation of leaf-bases is even more marked. The leaf-bases in our specimens are much narrower, and more elongate in proportion to their length, than those of *L. rimosum*. Further, the decorticated condition of *L. rimosum* does not correspond to our specimens.

Another near species is *Lepidodendron dichotomum* (Sternberg?), Zeiller, which, however, we believe to be distinct. Zalessky[4] has pointed out, and we understand that Dr. Kidston agrees, that certain of the specimens figured by the latter under the name of *L. Glincanum*[5] should now be referred to *L. dichotomum*. To return to *L. Glincanum*, our specimen is identical with Eichwald's[6] pl. v (*a*), fig. 5, and also to a less extent with figs. 1, 2, and 3; figs. 1 and 5 show the two stages of decortication, just as in our specimens. The specimens attributed by Schmalhausen to the same species—especially of those recently refigured by Zalessky[7]—correspond to our more external surface very fairly, though the leaf-bases are rather larger and the specimens are indifferently preserved. With regard to fig. 14, the correspondence is very close when compared with the decorticated surface of our specimen. The only other specimens so far figured with which we are acquainted are Kidston,[8] pl. v, figs. 41–3. Dr. Kidston's specimens do not show the decorticated stage. We must note that he calls this a variety '*rimosum*', while Zalessky refers it to the species *L. rimosum*. At any rate Dr. Kidston's specimens, from the River Esk, which he regarded as belonging to the Carboniferous Limestone Series, indicate that the locality is almost certainly high up in the Coal-measures.

This group of species, including *L. rimosum*, *L. Glincanum*, and *L. dichotomum*, is one which presents many difficulties, and further evidence may show that these forms are more intimately connected than is supposed. But for the present we have no good grounds for regarding them as other than distinct. The fact that the leaf-bases show no definite leaf-scar is also found to be usually the case in *Lepidodendron lanceolatum*, and may be characteristic of some of the Upper Coal-measure *Lepidodendrons*.

[1] Eichwald, *Lethæa Rossica*, vol. i, "Ancienne Période," p. 127.
[2] Kidston, Trans. Roy. Soc. Edinb., vol. xl, pt. iv, No. 31.
[3] Zalessky, *Mémoires du comité géologique*, N.S., 1908, livraison xiii, p. 88.
[4] Ibid., 1904, livraison xiii, p. 86.
[5] Kidston, Trans. Roy. Soc. Edinb., vol. xl, pt. iv, No. 31, pl. ii, figs. 20 and 21; pl. iv, figs. 37–9.
[6] Eichwald, *Lethæa Rossica*, vol. i.
[7] Zalessky, *Mémoires du comité géologique*, N.S., livraison xiii, pl. iii, fig. 13.
[8] Kidston, Trans. Roy. Soc. Edinb., vol. xl, pt. iv, No. 31.



E. A. N. A. photos.

Fossil Plants from the Bristol Coal-field.

The following list contains a complete record of the plants at present known from the four divisions of the Bristol district. It will be seen that the flora of the Farrington Series has been increased by twenty-one species, while the fossil flora of the Pennant Rock, the New Rock Series, and the Vobster Series remains as Dr. Kidston[1] recorded it, without a single addition.

FARRINGTON SERIES.

	Coal Pit Heath.	Parkfield.	Short-wood.	Puckle-church.
EQUISETALES.				
Calamites ramosus (Artis)	x	x	–	–
C. Suckowi, Brongn.	–	x	–	–
C. Cisti, Brongn.	–	x	–	–
Calamites (external surface)	–	x	–	–
Annularia stellata (Schloth.)	x	x	x	–
A. sphenophylloides (Zenker)	x	x	x	–
Annularia cf. *radiata* (?), Brongn.	x	–	–	–
SPHENOPHYLLALES.				
Sphenophyllum emarginatum, Brongn.	x	x	–	–
PTERIDOSPERMS AND FERNS.				
Sphenopteris neuropteroides (Boulay)	x	x	–	–
S. ovatifolia, n.sp.	x	–	–	–
Alethopteris Serli (Brongn.)	x	–	–	–
A. lonchitica (Schloth.)	x	x	–	–
Neuropteris flexuosa, Sternb.	x	–	x	–
N. macrophylla, Brongn.	–	x	x	–
N. ovata, Hoffman	–	x	x	–
N. Scheuchzeri, Hoffman	x	–	–	–
Pecopteris arborescens (Schloth.)	x	x	–	x
P. polymorpha, Brongn.	x	–	x	–
P. crenulata, Brongn.	x	–	–	–
P. Miltoni (Artis)	x	x	x	–
P. (*Dactylotheca*) *plumosa* (Artis)	–	–	x	–
P. oreopteridia, Schloth.	–	x	–	–
P. pteroides, Brongn.	–	x	–	–
Mariopteris muricata (Schloth.)	x	–	–	
Macrosphenopteris (?) sp.	–	x	–	–
Trigonocarpus Noeggerathi (Sternb.)	x	x	–	–
Trigonocarpus (outer surface)	x	–	–	–
Rhacophyllum spinosum, Lesqx.	–	x	–	–
R. crispum, Gutbier	–	x (?)	–	–
R. Goldenbergi, Weiss	–	–	–	x
Schizopteris lactuca, Presl	x	–	–	–
Caulopteris macrodiscus, Brongn.	x	–	–	–
LYCOPODIALES.				
Lepidodendron lanceolatum, Lesqx.	x	–	–	–
Lepidodendron cf. *Glincanum*, Eichw.	x	x	x	–
Lepidophyllum majus, Brongn.	x	–	–	–
Lepidophyllum (?) sp.	–	–	x	–
Sigillaria reniformis, Brongn.	x	–	–	–
S. Voltzia, Brongn.	x	–	–	–
S. elongata, Brongn.	–	x	–	–
Sigillaria (?) sp.	x	–	–	–
Stigmaria ficoides, Sternb.	–	–	x	–
CORDAITALES.				
Cordaites angulosostriatus, Grand'Eury	x	–	–	–

[1] Kidston, Trans. Roy. Soc. Edinb., vol. xl, pt. iv, No. 31.

PENNANT ROCK.

	Crews-hole.	Downend.	Fish-ponds.
EQUISETALES.			
Calamites Suckowi, Brongn.	x	–	–
C. cannæformis, Schloth., sp. ?	x	–	–
C. approximatus, Brongn.	x	x	x
LYCOPODIALES.			
'*Ulodendron*'	–	x	–
'*Halonia*'	–	–	x
Stigmaria ficoides, Sternb.	near Bristol.		

NEW ROCK SERIES.

	Kings-wood.	Kings-wood, Deep Pit.	Kings-wood, Speed-well Pit.	Warm-ley.	Golden Valley.	Bed-minster.
EQUISETALES.						
Calamites Suckowi, Brongn.	x	–	–	–	–	–
PTERIDOSPERMS AND FERNS.						
Sphenopteris trifoliata (Artis)	–	x	–	–	–	–
Pecopteris arborescens (Schloth.)	–	–	–	–	x	
P. Miltoni (Artis)	–	–	–	x	x	
LYCOPODIALES.						
Lepidostrobus sp.	x	–	–	–	–	–
'*Ulodendron*'	–	–	x	–	–	–
Sigillaria monostigma, Lesqx.	–	–	–	x	–	–
S. tessellata, Brongn. . . .	x	–	–	x	–	–
S. mamillaris, Brongn. . .	–	–	–	–	–	–
var. *abbreviata*, Weiss . .	x	–	–	–	–	–
S. scutellata, Brongn. . .	x	–	–	–	–	–
S. rugosa, Brongn. . . .	x	–	–	–	–	–
S. Schlotheimi, Brongn. . .	x	–	–	–	–	–
Stigmaria ficoides, Sternb. .	x	–	–	–	–	x
Cordaites (?) sp.	–	x	–	–	–	–

VOBSTER SERIES.

SPHENOPHYLLALES.

Sphenophyllum emarginatum, Brongn. . . . . Ashton.

PTERIDOSPERMS AND FERNS.

Pecopteris oreopteridia (Schloth.) . . . . Ashton.

LYCOPODIALES.

Sigillaria Sillimani, Brongn. . . . . Ashton.
S. mamillaris, Brongn. . . . . Ashton.

A Comparison of the Flora of the Farrington Series in the Bristol and Radstock Districts.

Fifty species in all have been recorded from the Farrington Series of the two districts. Seventeen of these are common to both the Bristol and Radstock areas, while twenty occur at Bristol which have not yet been found at Radstock, and thirteen at Radstock which are as yet unknown from Bristol. We have thus thirty species from the Farrington Series in the Radstock district; and thirty-seven species from the same series in the Bristol district, sixteen of which were recorded by Dr. Kidston and twenty-one by the present writer.

Turning now to a comparison of the Radstock and Farrington Series, only four out of the fifty species known from the Farrington Series are as yet unrecorded from the Radstock Series, which confirms Dr. Kidston's surmise that the two series belong to the same palæobotanical horizon, namely, the Upper Coal-measures. The four plants from the Farrington Series which have not yet been definitely found to occur in the Radstock Series are the following:—

Sphenopteris ovatifolia, n.sp.
Schizopteris lactuca, Presl.
Lepidodendron cf. *Glincanum*, Eichwald.
Sigillaria principis, Weiss.

But as mentioned above (p. 62), a *Sphenopteris*, very like *S. ovatifolia*, has been found in the Radstock Series of Somerset, at Kilmersden, by Mr. Arber.

In conclusion, I would express my special thanks and indebtedness to Mr. Arber for suggesting that I should take up the work in the first place, and for continued help and advice throughout. Many thanks are due to Mr. H. Bolton, F.G.S., of the Bristol Museum, for his kindness in handing over to me the petrified material from Staple Hill for examination; and to Mr. James McMurtrie, F.G.S., of Bristol, for much local help and information.

EXPLANATION OF PLATE VII.

(Photographs by Mr. Arber.)

Fig. 1. *Lepidodendron* cf. *L. Glincanum*, Eichw. Stem showing two states of preservation—(*a*) slightly decorticated outer surface showing the leaf-bases, but not the leaf-scars; (*b*) more decorticated state. × $\frac{3}{2}$. No. 2080. Sedgwick Museum, Cambridge.

,, 2. The same. Portion of the slightly decorticated outer surface, showing the leaf-bases. × $\frac{3}{2}$. No. 2068.

,, 3. Portion of the same stem as Fig. 1, showing two similar states of decortication.

,, 4. *Sphenopteris ovatifolia*, sp. nov. Typical pinnæ. × $\frac{5}{4}$. No. 2089.

,, 5. *Sphenopteris ovatifolia*, sp. nov. A portion of a frond. × $\frac{3}{2}$. No. 2086.

III.—Note on the Faunal Succession in the Carboniferous Limestone (Avonian) near Llantrisant Station in the Bridgend Area, South Wales.

By G. Delépine, Professor of Geology at the Catholic University, Lille.

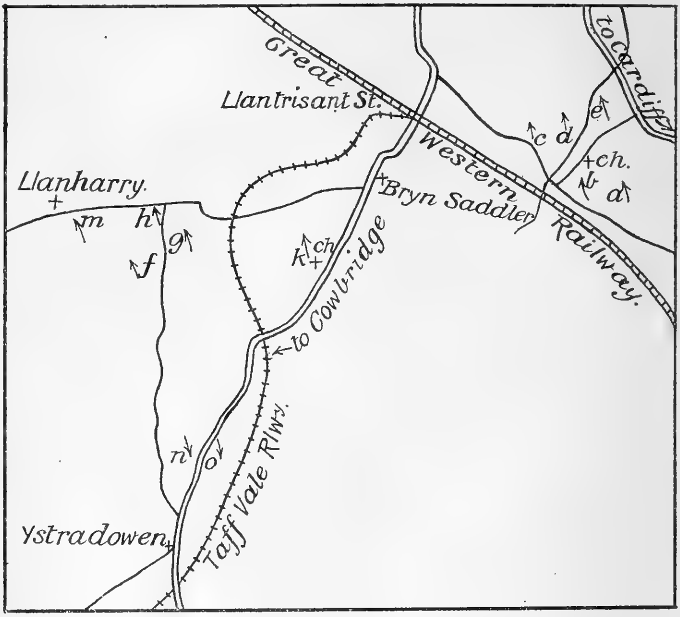
During the autumn of 1909, I made a short excursion into the Bridgend district and examined the Avonian sequence near Llantrisant. The present note embodies the results of a few traverses and suggests a correlation with the sequence already established at other points of the South-West Province.

I herewith acknowledge my indebtedness to Dr. A. Vaughan, F.G.S., for the loan of specially prepared 6 inch maps, and for help in drawing up the faunal lists given below.[1]

The strike of the limestone is generally W.S.W. and the dip N.N.W., in the neighbourhood of Llantrisant and Llanharry (see

[1] The specific identification is that adopted by Dr. Vaughan in his papers on the Avonian.

sketch-map), but near Ystradowen the beds turn over locally and dip S.S.E. (see the new 1 inch map, Geological Survey, Sheet 262).



Sketch-map of the Carboniferous Limestone exposures near Llantrisant Station.

I. *Exposures East of Llantrisant Station, North of the Great Western Line.*

(1) About half a mile east of Miskin church (sketch-map, letter *a*) there are several small and scattered exposures which exhibit a thin-bedded dark-grey encrinital limestone. From these beds I obtained the following Brachiopods:—

Productus burlingtonensis.
Chonetes cf. *hardrensis.*
Orthotetid.
Rhipidomella Michelini.
Spirifer clathratus.
Syringothyris cf. *typa*, Weischell.
Reticularia cf. *lineata.*
Athyris cf. *glabristria.*
Rhynchonellid.

Bryozoa, especially Fenestellids, are very abundant.

(2) About 200 yards north of exposure *a*, in an old quarry (exposure *b*) near the school, black and dark-blue encrinital limestone occurs at the bottom and dolomite with crinoids above.

The limestone yielded—

Corals.

Zaphrentis sp.
Caninia cornucopiæ.

Brachiopods.

Productus burlingtonensis.
P. cf. *pustulosus.*
Chonetes cf. *hardrensis.*
Spirifer clathratus.
Syringothyris laminosa.

The dolomite yielded—

Caninia cornucopiæ.
Syringothyris cuspidata.
S. laminosa (very common).

(3) In a quarry near Hendy Farm, along the road from Miskin to Pontyclun (exposure *c*), encrinital dolomite and massive oolite are observed.

FAUNA.

Cyathophyllum φ.
Productus corrugatus, var.
Syringothyris cuspidata.
S. laminosa.
Athyris ingens, de Kon. (= *Athyris* cf. *glabistria*, mut. C–S).

(4) Along the road, north of Miskin, which joins the main road from Llantrisant to Cardiff, there are two quarries, to left and right of the road respectively.

In the first of these (exposure *d*) the ascending succession is as follows:—

Encrinital dolomite and oolite.
Thin-bedded black limestone ('china-stone').
Massive oolite.
Blue and grey well-bedded limestone.

The dolomite at the base contains the same fossils as exposure *c* near Hendy Farm.

The upper beds contain—

Lithostrotion Martini.
Productus corrugato-hemisphericus.
Seminula ficoides (abundant).

The second quarry (exposure *e*) lies to the north of the last, and about 100 yards distant.

The oolitic limestone here contains—

Productus cf. *corrugatus*
Prod. corrugato-hemisphericus
Seminula ficoides
} All abundant.

As has been previously noticed, a variant of *Prod. corrugato-hemisphericus* approaches close in form to *Prod. striatus.*

IA. *Correlation of the Limestone East of Llantrisant with the Avonian of the South-West Province.*

The exposures described above fall readily into the following positions on the zonal scale:—

Seminula-zone { S_2 = Exposure *e*. / S_1 = Exposure *d* (top of quarry only).
Caninia-zone { C_2 = Exposure *c* and bottom of Exposure *d*. / Base of C_1 (γ) = Exposure *b*.
Zaphrentis-zone (pars) = Exposure *a*.

II. *Exposures West of Llantrisant Station, near Llanharry.*

There are several quarries in S_2 and Lower D on the left of the road from Bryn-Sadler to Llanharry.

(1) In a quarry some half-mile south-west of Llanharry Station

(Taff Vale Railway) and on the road from Llanharry to Ystradowen (exposure *f*) the following fossils occur in a massive oolite :—

Lithostrotion.
Carcinophyllum.
Prod. corrugato-hemisphericus, mut. S_2.
Seminula ficoides.

(2) A large quarry and several small ones.

Above this oolite, in a very large quarry (exposure *g*) north of, and close to, Llanharry Station, a well-bedded blue and violet limestone is massively developed.

Here the beds are poorly fossiliferous, but in another quarry (exposure *h*) where the upper beds are worked I collected—

Carcinophyllum θ and fragments of *Campophyllum* and *Productus.*

In a quarry to the east of the last, near a chapel, on the other side of the Taff Vale line, a similar limestone occurs (exposure *k*). This yielded *Productus hemisphericus, Chonetes* sp., and Gasteropods.

(3) Close to the village of Llanharry, on the left-hand side of the road from Bryn-Sadler, is an old quarry (exposure *m*) exhibiting thick beds of rubbly limestone. Here I collected—

Lithostrotion irregulare.
Dibunophyllum θ.
Productus near *Martini.*
Seminula ficoides.

IIA. *Correlation of Limestone West of Llantrisant with Avonian Zones.*

Dibunophyllum-zone	D_2 = Exposure *m*.
	D_1 = Exposure *h*, and perhaps top of large quarry (*g*).
Seminula-zone.	S_2 = Exposure *f* and bottom of large quarry (*g*).

III. About one mile north of Ystradowen, on both the right and left of the main road from Llantrisant to Cowbridge, the beds dip in a south-easterly direction.

A quarry on the right (exposure *n*) exhibits dolomite with crinoids; the base of the dolomite yielded—

Syringothyris laminosa (abundant).
Syr. cuspidata (common).
Caninia cornucopiæ.

A quarry on the left (exposure *n*) exhibits, in ascending order—

(1) Massive oolite.
(2) Dolomite with crinoids.
(3) Black limestone.

The beds in (*n*) and (n^1) resemble, both lithologically and palæontologically, the oolitic and dolomitic beds of exposure (*c*), near Hendy Farm, which have been assigned to C_2.

Zonal Sequence	*Dibunophyllum*-zone	D_2	*m*.
		D_1	*h*, top of *g* (*k*?).
	Seminula-zone	S_2	*e, f*, bottom of *g*.
		S_1	Top of *d*.
	Caninia-zone	C_2	Bottom of *d, c, n*, n^1.
		Base of C_1 (γ)	*b*.
	Zaphrentis-zone	. . . . .	*a*.

IV.—On the Origin of the Nile Valley and the Gulf of Suez.[1]

By John Ball, Ph.D., D.Sc., F.G.S.

In Captain Lyons' *Physiography of the River Nile and its Basin* (Cairo, 1906, p. 294), there occurs the following statement:—

"In a trough from 2 to 10 kilometres wide and 100 to 300 metres deep lies the Nile, meandering through a flood plain formed by yearly deposits of silt brought down from the Abyssinian table-land by the Blue Nile and the Atbara. This trough was determined in the first instance by fractures of the crust which caused a strip of country from about Edfu (lat. 25° N.) to Cairo to be depressed, leaving the plateau standing high above it, just as the Red Sea and the gulfs of Suez and Akaba were formed, probably about the same epoch. This interference with the drainage of the country doubtless produced a series of lakes in the low-lying area, while the drainage of the eastern plateau commenced to excavate the valleys which now exist as dry desert wadies, their development being in many cases far from complete, as shown by the cliffs which interrupt the slope of the valley when a harder bed of rock than usual is met with.

"Into this depressed area the drainage of the southern part of the basin finally flowed, and there laid down the alluvial deposit through which the river flows to-day."

A clear and definite pronouncement of this kind, coming from so high an authority as the former Director-General of the Geological Survey of Egypt, is likely to convey the impression that the 'rift theory' of the origin of the Nile Valley and Gulf of Suez is supported by evidence which leaves no room for any other view. This is very far from being the case. To my mind the field-evidences are entirely against the 'rift theory'; they point rather to the Nile Valley being essentially a valley of erosion (though faults or lines of weakness may have had something to do in influencing the river's course), and to the Gulf of Suez being an eroded anticline.

During my twelve years of survey work in Egypt, most of which has been spent in geologizing, I have felt myself becoming increasingly sceptical as to the truth of the 'rift theory' of the orgin of the Nile Valley and the Gulf of Suez. But it was not till the spring of the present year, when I examined the geological structure of the Wadi Araba and part of the Gulf of Suez, that I obtained evidence which appears to be absolutely convincing against the 'rift' view cited above.

The Wadi Araba is a great valley some 20 miles wide, draining north-eastwards into the Gulf of Suez between latitudes 29° 3′ and 29° 22′ N. It divides two great plateaux, the North and South Galala Mountains, which rise to heights of over 4000 feet. The faces of the plateaux which shut in the valley are steep cliffs, in which are exposed a great thickness of Eocene limestones, overlying Cretaceous limestones, marls, and clays, with Nubian Sandstone at the base. The beds, especially the lower ones, have a well-marked dip into the scarp, showing the valley to be an eroded anticline; and this structure is confirmed by the fact that as one crosses the valley, deeper and deeper

[1] By permission of the Director-General, Survey Department.

sandstone-beds come to the surface, until near the centre of the valley one comes on Carboniferous rocks in the form of thin limestone-beds, intercalated in the sandstones, with abundance of such characteristic fossils as *Spirifer* and *Productus*. There is no apparent unconformity anywhere in the series. The upper sandstone beds, which are devoid of fossils, may therefore be here, as in the Nile Valley, of Cretaceous age, though the lower ones are certainly Carboniferous. The apparent absence of any unconformity between Cretaceous and Carboniferous is a very striking fact; but it is not material to the argument concerning structure, the great point in this connexion being the absolute proof, furnished by the succession of fossiliferous beds, and their dips, that the Wadi Araba is an eroded anticline, and thus the very opposite of a rift or trough-fault.

Another very significant feature of the valley is the way in which great masses of the hard Eocene limestones have been let down by landslips at the faces of the limiting scarps, often forcing the softer Cretaceous beds below them outwards into highly-tilted, or even nearly vertical, positions. Two causes may have worked to produce this. The softer, lower beds may have been eroded out so as to undercut the upper, harder ones, and bring about their fall; cracking of the beds may have occurred during the formation of the anticline, which would help in the separation of the masses. Further, it would appear at least a possible explanation that the stresses set up by the daily expansion and contraction of the plateau-surface under the influence of the enormous diurnal variation of temperature may have produced clefts near the free edges of the plateaux; and masses detached in this way on even a slight slope would tend to creep lower and lower under continual expansion and contraction. But whatever the cause of this faulting-down at the face, it is at least certain that it is only landslipping on a large scale, and has nothing to do with the main tectonic structure of the valley. The Wadi Araba is an eroded anticline, its limiting scarps showing in places a step-like structure, due to local slipping down of the hard upper strata at the cliff-face.

I have dwelt thus long on the Wadi Araba, because, while it presents the same phenomena as the Nile Valley and the Gulf of Suez on a magnificent scale, it possesses also the advantage, not shared by them, of being entirely exposed, so that one can examine its floor with the same care and detail as its sides. If the floor of the Wadi Araba were covered with alluvium or water, we should have an almost exact resemblance to the Gulf of Suez and the Nile Valley.

Turning now to the Gulf of Suez, which lies in close connexion with the Wadi Araba, though at right angles to it, an exactly similar, albeit somewhat more restricted, series of observations can be made. Leaving the Wadi Araba, I journeyed northwards along the coast, skirting the scarps of the North Galala plateau, which in places come so abruptly down to the sea that camels have to wade through the sea to round the bluffs. The Carboniferous beds, with their characteristic crinoids, were traced as far north as 29° 30′ of latitude, showing clearly that the eastern foot of the North Galala plateau exposes Carboniferous strata at its base. The North Galala plateau is thus thrust upwards along the western shore of the gulf, the beds dipping generally westwards. This is confirmed by the gradual rise eastwards of levels of the springs, and of the junction of Cretaceous and Eocene beds as one skirts the north scarp of Wadi Araba.

My observations of the other side of the gulf were only telescopic. But even casual scrutiny of the hills of the opposite shore (Gebel Hammam) showed the beds there to be dipping markedly away from the gulf. Telescopic observations of geological structure are always to be received with caution, but in this case my observations are confirmed by those of my late lamented colleague, Mr. Barron, who, from an actual examination of the place, records [1] that the strata of Gebel Hammam dip 10° eastwards.

So far as general structure goes, therefore, the beds on the two sides of the Gulf of Suez dip away from the gulf, showing the gulf to be an anticline.

The seaward faces of the North Galala plateau exhibit in many places a step-like form due to the faulting down of the strata in the same manner as those of the Wadi Araba, and at several points the faults are cut through by small lateral valleys which allow of their easy examination. The impression produced in all these cases is that of land-slipping at the face of the scarp, and not that of the letting-down of a tract extending across the gulf. One of the best exposures is the north face of a hill-mass in latitude 29° 34′, close to the north-east corner of the North Galala plateau. I climbed this hill, on which I had a trigonometrical station 1295 feet above sea-level, and found its lower part to be composed of yellow-brown and white limestone and marls (Cretaceous), while its upper part was mainly hard limestone, which I believe to be chiefly Eocene with a thin covering of Miocene. The whole of the beds dipped strongly (18° to 25°) towards the main scarp. Standing on the hill-top, one can see, high up on the main scarp to the west, the same Cretaceous limestones and marls which form the foot of the hill, while the hard Eocene limestones cap them at a height of over 2000 feet. Proceeding a short way along the coast north of this hill, one can obtain a very clear view of the faulting. The fault or slip-plane is inclined at only 22° to the horizontal, of course downward from the scarp, and the faulted-down Eocene limestones of the hill abut against the purple and brown sandstones and clays (possibly in part Carboniferous) which form the lower part of the main scarp. The flat angle of the fault-plane is significant, and points far more to a great landslip at the face of the scarp than to organic faulting of the earth's crust. The high dip of the slipped-down beds towards the scarp is also entirely against trough-faulting of the gulf; for if the beds ever extended far seawards with anything like the same dip, they would have attained a height much greater than that of the main plateau. The conclusion seems justified, therefore, that the faulting along the shore of the gulf is purely land-slipping, and has nothing to do with the main tectonics of the gulf. In other words, the Gulf of Suez, like the Wadi Araba, is not a trough-fault, but an eroded anticline.

[1] *Topography and Geology of the Peninsula of Sinai (Western Portion)*, Cairo, 1907, p. 30.

It will of course be remarked that an immense amount of erosion must have gone on in the gulf to remove the folded-up strata, while the trough-fault theory would not demand this. But one has to remember that in the case of the Wadi Araba there can be no doubt of erosion on this immense scale having taken place; for it is impossible to doubt the original continuity of the Eocene over the Wadi Araba, and the Carboniferous beds in the wadi-floor show that the Eocene has not been faulted down, so that it must have been eroded out. Vast ages must have been occupied in this erosion, even if it took place *pari passu* with the folding of the anticline. But with the greater space of time which physicists now allow us for the earth's evolution since the discovery of radio-active minerals, geologists will not feel that the time demanded for the erosion is any obstacle to believing it to have taken place.

The conviction that the Gulf of Suez is an eroded anticline and not a trough fault at once removes an important support from the 'rift theory' of the Nile Valley. For both the Nile Valley and the Gulf of Suez have on this theory been regarded as due to earth-movements of similar type acting about the same time, and if we show the movements postulated to have been non-existent in the one case, a doubt at once arises about the other.

I have made a search through the various publications to find out the history of the 'rift theory' as applied to the Nile Valley and the evidence relied on for its support. The earliest reference published appears to be in a paper read by my friend and former colleague Mr. Beadnell at the International Geological Congress at Paris in 1900, an abstract of which appeared in the Geological Magazine of January, 1901 (p. 23). Though Mr. Beadnell informs me that he no longer considers the trough-faulting of the Nile Valley to be a necessary conclusion from his observations, he has set out so clearly in his paper the only grounds on which the 'rift theory' rests, that it is advisable to quote them here as affording a definite basis for discussion. The facts which led Mr. Beadnell to the view that the Nile Valley had its origin in earth-movements and was not the result of erosion are as follows:—

(1) The general north and south direction of the Nile Valley in Egypt.

(2) The remarkable high, lofty, wall-like cliffs by which it is hemmed in.

(3) The absence of any true river-deposits at any considerable height above the river.

(4) The almost entire absence of hills or outliers of the plateau within the valley.

(5) The proved existence of bounding faults throughout a long stretch of the valley.

The whole weight of the evidence lies in the last fact given, the first four having but little significance in themselves. As regards the general direction of the valley, it is by no means straight; the greater part of it is approximately parallel with the Gulf of Suez, but if that gulf is not a trough there is no argument by analogy of direction.

The nature of the cliffs is no more evidence of faulting here than in the case of the Grand Cañon of Colorado. Moreover, cliffs of the same character occur in many lateral valleys, and any argument as to the one applies equally to the other; this difficulty was clearly perceived by Dr. Blanckenhorn,[1] who in accepting the trough-fault theory for the valley ascribed the origin of many of the lateral wadies to faulting. The absence of high river-terraces is easily explained by the frequent landslips at the face of the scarp and the action of the sand-blast through long ages. Outliers of the plateau within the valley would necessarily be infrequent on a theory of river-erosion without faulting. As to the bounding faults, there is no doubt whatever of the accuracy of Messrs. Barron and Beadnell's observations of the facts. I have seen many of the places myself and confirmed their sections. But one may dissent from their interpretation. The faulting observed is by no means continuous; it is most pronounced where soft, shaly beds have formed the base of the main scarp; no observation has ever been made of faulted-down rocks far from the scarps; and the faulted-down portions are exactly similar to those which occur in the oases, in the Wadi Araba, and along the coast of the Gulf of Suez, wherever there is an exposed face of a great plateau without any suggestion of trough-faulting. The true interpretation of the bounding faults of the valley is that they are landslips, and have nothing to do with the primitive formation of the valley. The valley was eroded first, and the landslips occurred afterwards. Faults or lines of weakness may have influenced the path of the river in its early stages, but the material which formerly extended from cliff to cliff has been removed seawards by erosion, not let down under the present Nile-bed. The great eastern wadies were formed contemporaneously with the Nile Valley by the same process of erosion, being the paths of tributary streams. They are on a scale quite comparable with the main valley, and there is no evidence whatever to support the view expressed by Captain Lyons that they originated after the main valley was formed. That the Nile Valley is geologically young is undoubted, but I know of no facts which would support the belief that it is of insufficient age for it to have been entirely excavated by erosion.

After coming to the above conclusion, I have had the pleasure of discussing the matter with Mr. Beadnell, who informed me that he has for some time abandoned the trough-fault interpretation of his observations, and he authorizes me to state that he has lately convinced himself that all the faults along the scarps of the Nile Valley can be explained as landslips, the harder limestones having slipped down over the softer underlying shales which have been eroded by the river.

Conclusions.

(1) The hypothesis that the Nile Valley and the Gulf of Suez owe their origin to trough-faulting is unwarranted by geological evidence.

(2) The Gulf of Suez is an eroded anticline.

(3) The Nile Valley is essentially a valley of erosion, and the

[1] "Geschichte des Nilstroms": Zeits. für Erdkunde, Berlin, 1902.

eastern wadies draining into it were formed contemporaneously, also by erosion.

(4) The faulting, which can be observed along the faces of the bounding scarps of the Nile Valley, Gulf of Suez, and the eastern wadies, is the result of landslips subsequent to the erosion of the hollows.

V.—Notes on new or imperfectly known Chalk Polyzoa.

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

(PLATE VIII.)

(Continued from the January Number.)

Membranipora invigilata, nov. Pl. VIII, Figs. 1 and 2.

Zoarium adherent.

Zoœcia roughly elliptical, length ·60 to ·68 mm., width ·36 to ·40 mm., length of area ·36 to ·40 mm., width ·24 to ·28 mm.; they have broad side walls, whose upper surfaces slope slightly to the area; at the foot there is generally a fair amount of external front wall, which often carries its own accessory avicularium or the oœcium of the preceding zoœcium; the walls of adjacent zoœcia are always distinguishable and very often not in contact.

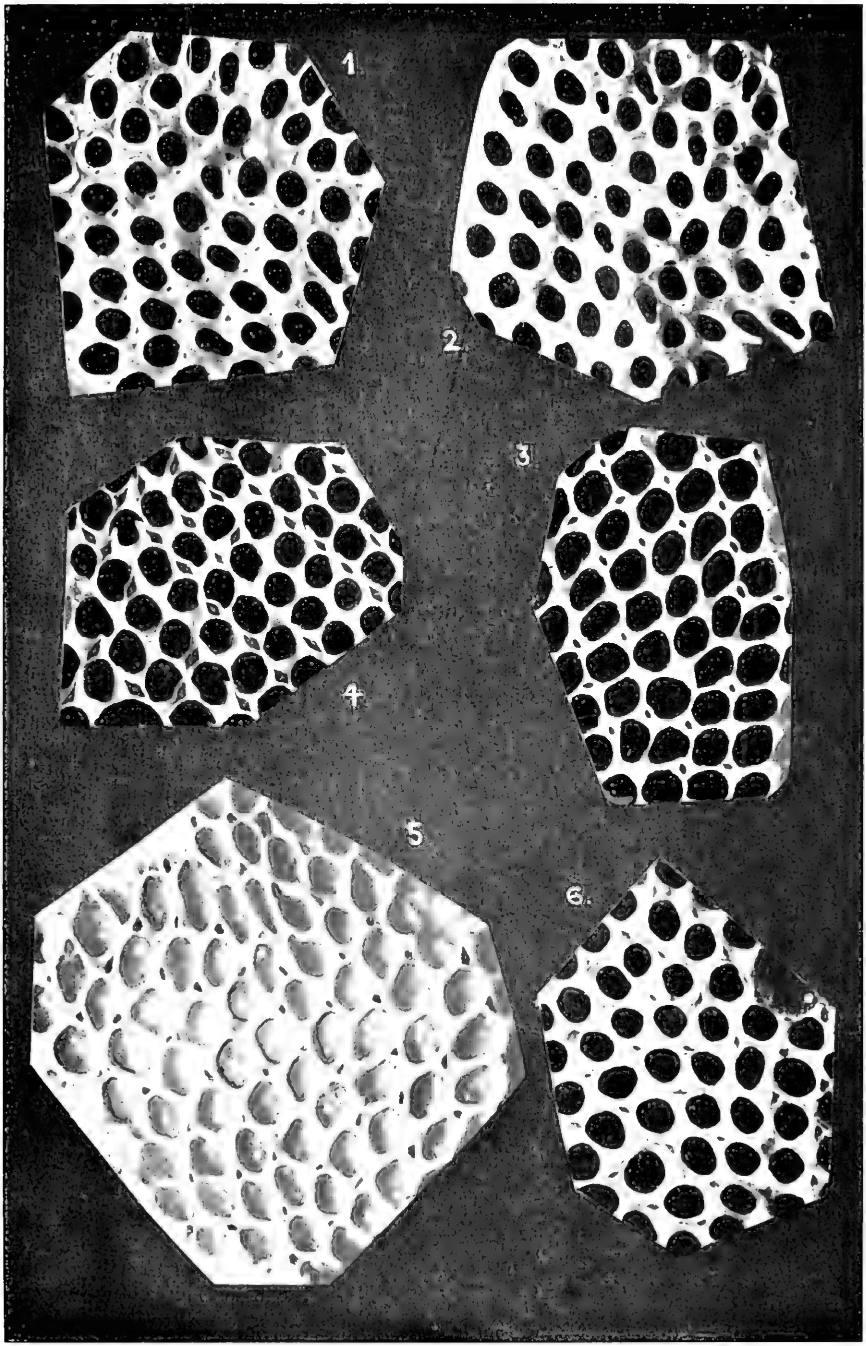
Oœcia abundant but very rarely preserved, globose, with a small part of the under edge free.

Avicularia of two types. (*a*) Accessory: these are small semicircular tubular prominences developed on a semi-elliptical platform pushed out over the external front wall below the level of the rims of the area; they are directed forwards, looking over the area and sometimes overhanging it; sometimes the platform is formed without any further development, except perhaps a perforation. (*b*) Vicarious: these are long and narrow, widest at the head and tapering gently to the foot; aperture similar in outline, but with a construction of very variable degree near the foot, and bounded at the head by a broad internal shelf at some depth, which tapers rapidly towards the middle, where it disappears; at this point the bounding walls are folded over so that the outer edge in the upper part becomes the inner edge in the lower (well shown by the avicularium, which in Fig. 1 is immediately to the left of the only oœcium preserved).

Fairly common at Trimingham and in the zone of *Micraster coranguinum* at Gravesend, and I have found what may be a spinose stage of it in the zone of *Actinocamax quadratus*. *M. trigonopora*, Marss., has a general resemblance to this species, but has no vicarious avicularia, while this species has not the tiny pores of *M. trigonopora*.

Membranipora Britannica, mihi. Pl. VIII, Figs. 3 and 4.

I take this opportunity of giving photographs of the type-specimen (Fig. 3), and another with finely developed avicularia (Fig. 4). In a *Membranipora* so abundant almost any micrometric measure can be obtained, but ·36 to ·48 mm. for length of area and ·28 to ·32 mm. for



R. M. Brydone photo.

Chalk Polyzoa.

width of area seem fairly representative. The specimen shown in Fig. 4, though very exceptional in its large and graceful avicularia, quite 99 per cent. of specimens conforming closely with the type, raises an interesting question whether Fig. 3 ought to be regarded as the true standard and Fig. 4 as a sport, or whether Fig. 4 ought to be regarded as the true standard and Fig. 3 as due to mechanical causes—attrition and solution—or to the general prevalence of some local condition unfavourable to a full development of the avicularia. As the two specimens grew contemporaneously and under identical conditions, so far as can now be judged, the question is more acute than in such a case as *Cribrilina Gregoryi*, where the avicularia are mere rings until we get high up in the zone of *Act. quadratus*, where they become mandibular.

MEMBRANIPORA BRITANNICA, var. PRÆCURSOR, nov. Pl. VIII, Fig. 5.

This is the form which occurs in the Upper Senonian, especially in the zones of *Act. quadratus* and *Belemnitella mucronata*. The zoœcia are distinctly shallower, longer, and wider than in the type, the walls of adjacent cells are practically always distinguishable, and the avicularia lie practically on their backs and along the surface of the zoarium and with their long axes nearly parallel to those of the zoœcia. The oœcia are so fragile that I have not yet seen one preserved. Length of area ·48 to ·64 mm., width ·36 to ·40 mm.

MEMBRANIPORA BRITANNICA, var. DEMISSA, nov. Pl. VIII, Fig. 6.

This form occurs not unfrequently at Trimingham. It is intermediate between the type and the var. *præcursor* in that its avicularia lie along the surface of the zoarium, with their long axes nearly parallel to those of the zoœcia, but distinctly on their sides. It is clearly distinguished from both by its pyriform zoœcia with considerable extent of front wall. The type does, it is true, often show a local tendency towards a pyriform zoœcium with front wall, but this always appears to be due either to crowding, which forced the zoœcium to grow some distance before it could open out its area, or to the failure of the preceding zoœcium to produce an avicularium or an oœcium to occupy the space provided for it; the tendency does not go farther than may be seen here and there in Fig. 4. In the var. *demissa* the pyriform shape is obviously a fundamental character (which might be held to justify a specific separation), and is developed concurrently with the provision for the avicularium of the preceding zoœcium. Besides these specific points of difference there is a considerable difference in matters of degree which is incapable of any exact definition, but which makes the variety readily recognizable with a pocket magnifier. Length of area ·36 mm., width ·32 mm.

EXPLANATION OF PLATE VIII.

FIG. 1. *Membranipora invigilata.* Chalk of Trimingham. × 20.
,, 2. Ditto, another specimen. Ditto. × 20.
,, 3. *Membranipora Britannica*, type-specimen. Ditto. × 20.
,, 4. Ditto, another specimen. Ditto. × 20.
,, 5. Ditto, var. *præcursor*. Zone of *Actinocamax quadratus*, Winchester. × 20.
,, 6. Ditto, var. *demissa.* Chalk of Trimingham. × 20.

VI.—On the Discovery of *Archæosigillaria Vanuxemi* (Göppert) at Meathop Fell, Westmorland, with a Description of the Locality.

By J. Wilfrid Jackson, F.G.S., Assistant Keeper of the Manchester Museum.

In September last I discovered a number of plant remains in the Carboniferous Limestone at Meathop Fell, Westmorland, amongst which were several fragments of what, at first sight, looked like a species of *Lepidodendron*. A closer examination, however, of one or two of the better preserved specimens, which showed traces of leaf-scars, at once suggested *Archæosigillaria Vanuxemi*, specimens of which I had previously seen in the Kendal Museum.

On a later visit to Meathop Fell I was successful in obtaining a number of other fragmentary specimens of the same plant, along with a specimen of a cone, which from its position and association with branches of *A. Vanuxemi*, has every appearance of belonging to that species. Unfortunately the branch bearing it is so badly preserved that no definite details can be made out, hence there is no conclusive proof that it belongs to the above species. This is all the more unfortunate, as, up to the present, the fructification of this interesting plant is unknown.

The majority of the plant-remains found appear to be referable to the above species, but one or two specimens occurred which looked like the flattened stems of other plants. The identification of these, however, is impossible, owing to their badly preserved condition. I also obtained a portion of the stem of *Bothrodendron* sp., which will be referred to later.

The present discovery of *A. Vanuxemi* constitutes the third recorded occurrence of the species in Britain. The first British specimens, which are in the Kendal Museum, were brought to the notice of Dr. Kidston by Mr. R. Bullen Newton, F.G.S., and were described in 1885 as *Lycopodites* (*Sigillaria*) *Vanuxemi*.[1] These specimens were collected from the lower beds of the Mountain Limestone, near Shap Toll-bar, Westmorland. In 1899 Dr. Kidston created the new genus, *Archæosigillaria*, for the reception of this plant.[2]

The second discovery was made near Dyserth, North Wales, by Dr. Wheelton Hind, F.R.C.S., etc., and Mr. J. T. Stobbs, F.G.S.[3] Here the species was fairly common, and was associated with a fauna characteristic of S_2.

It may be of interest here to call attention to the fact that the type of the species was discovered in the Upper Devonian (Chemung Group) of New York, but all the British examples originate from a higher horizon.[4]

Description of the Meathop Specimens.

Archæosigillaria Vanuxemi (Göppert).

The largest specimen I obtained measures 18 cm. in length, the width of the branches being from 8 to 10 mm. It exhibits very clearly the dichotomous branching of the species, but owing to the branches being flattened by pressure and rather badly

1 Journ. Linn. Soc., Botany, vol. xxi, p. 560, pl. xviii.
2 Trans. Nat. Hist. Soc. Glasgow, n.s., vol. vi, p. 38.
3 Geol. Mag., 1906, p. 391, and Rep. Brit. Assoc. for 1906, p. 303.
4 Journ. Linn. Soc., Botany, vol. xxi, p. 565.

preserved, the leaf-scars are not shown to advantage. The slab containing this specimen also shows a cross section of a species of *Syringopora*, and contains several specimens of *Seminula* sp. On the back of the slab is a portion of a branch bearing the cone referred to previously, and I found on development that the branch continued through the stone to the other side, where faint traces of it were visible a little to one side of the branches just described. The cone appears in section, the separation of the slab having passed through its central axis. Both halves exhibit very clearly a long peduncle coming off at right angles to the stem. This is clothed with acicular bracts for a distance of three-quarters of an inch, where traces of sporophylls, ending in long points, begin to appear. The cone has a width of about half an inch, and measures $2\frac{1}{4}$ inches in length, including the peduncle, but has undoubtedly been much longer, as the top portion is missing. Owing to its bad state of preservation, no further details can be made out with certainty.

On another fragment of limestone, a portion of a dichotomously divided stem occurs, which exhibits, fairly well, the characteristic hexagonal leaf-scars of the older branches of *A. Vanuxemi*. These scars are rather longer than broad, and measure 4·5 mm. by 3 mm., the width of the stem being 9 mm. No vascular cicatricule, however, can be made out.

Bothrodendron sp.

This consists of a flattened portion of a large stem, which has come out free from the matrix. It measures $5\frac{1}{2}$ inches in length, $2\frac{1}{2}$ to 3 inches in breadth, and is 2 inches in thickness. The surface is a mere film of carbonaceous matter, on which leaf-scars are distinctly visible in several places. These scars are 7 mm. apart, disposed in rows 10 mm. apart, each row winding round the stem in the usual rapidly ascending manner. The specimen is too badly preserved to be specifically identified.

Topography and Geology of Meathop Fell.

Meathop Fell, which lies about a mile and a half east of Grange-over-Sands, is an isolated exposure of Carboniferous Limestone, surrounded on all sides by alluvial flats and salt-marsh. It is a little more than a mile in length, and just over half a mile in breadth; its greatest height above sea-level is 179 feet. On its south-east side it is cut off, by the Kent Estuary, from the Arnside Beds, which come next in succession. The exposure may be described as being made up of a series of beds of impure limestone, more or less dolomitic, separated at intervals by thin earthy bands. The limestone is extremely hard, compact in texture, and breaks with a conchoidal fracture. It has been much quarried for strong plain work, such as engine beds, foundations, etc., but is not suitable for sculpture. The general dip of the beds is at a very low angle, it being about 8° S.E.

Fossils are not numerous in species, but large masses of *Syringopora*, along with a few small Cyathophyllids, etc., occur weathered out in relief on the cliff face, especially at Meathop Fell end. The *Syringopora* appear to consist of two forms; in one case the corallites are very small, not more than $\frac{1}{16}$ of an inch in diameter, geniculated, and with fairly numerous connectors; in the other case the corallites are distinctly larger, closely set, and possess a thick wrinkled epitheca; connectors fairly numerous, walls of corallites rather thick; diameter about 1 line. This form agrees very closely with *S. geniculata* of Edwards & Haime's figs. 2 and 2*a* of plate xlvi.[1]

Near the top of the Fell, an impure limestone band, several inches thick, occurs, which appears to be entirely made up of specimens

[1] *A Monograph of the British Fossil Corals*, 1852 (Pal. Soc.).

of *Seminula* sp. (cf. *ficoidea*), nearly all of which have the two valves adherent. Many of the specimens, however, are much crushed and broken. Occasional examples of single valves may be found which exhibit their Athyrid characters remarkably well. On the weathered faces of this bed, very definite lines of stratification may be observed, alternating between the layers of shells. The only other species, so far, noticed in this band is a small fragment of an *Athyris* showing concentric lamellation. There is a possibility of some of the others being *Athyris* also, which have lost their outer layer and therefore resemble *Seminula*. In its general appearance this band bears a striking resemblance to a modern sea-beach, where shells are thrown up in hundreds; and it may, in all probability, represent an old shore-line. The same form of *Seminula* also occurs scattered through the beds below the above-mentioned band.

At the top of the Fell, at the Meathop Fell end, I obtained the following species: *Spirifer* cf. *furcatus*, M'Coy[1] (abundant), *Reticularia* aff. *lineata* (Martin) (rare), and one or two others too imperfect to identify with safety. Other species collected at various parts of the Fell are, *Psammodus rugosus*, Ag. (fragment of tooth), *Euomphalus* sp. (cast), *Fenestella* sp., *Seminula* (? *ambigua*), and *Productus* aff. *corrugatus*, M'Coy.

The plant bed is apparently not exposed at the southern end of the Fell, as I have never seen any traces of it here. Where it does crop out is some little distance to the north. Associated with the plant remains are some small Seminulas and a *Syringopora* of a small ramulose type, which does not appear to have received a name yet. In beds immediately above, masses of *Syringopora* occur in abundance, and where these beds crop out at the surface large specimens may be obtained beautifully weathered out and free from matrix. With regard to the species of *Syringopora*, Dr. Sibly, to whom I submitted specimens, has no hesitation in calling it a small variety of *S. geniculata*, using that name merely as a group name, and adopting Edwards & Haime's interpretation of the name. He says it is distinctly smaller than the *S.* cf. *geniculata* which abounds in D_1 of the South-West and the Midlands, but is of the same type.

It is perhaps premature to attempt to fix definitely the exact horizon of these beds, as they appear to have been, as yet, but superficially studied.

As already mentioned in the North Wales exposure, *A. Vanuxemi* occurs in beds which are assigned to the S_2 subzone. In the Shap exposure, the exact horizon and fossil associates of *A. Vanuxemi* are, unfortunately, not so well known. My friend Canon Crewdson, honorary curator of the Kendal Museum, tells me that the Shap Toll-bar quarry (now closed), from which their specimens came, is about 1½ miles south of the village. He has since found the species in an old quarry at the northern end of the village, but cannot remember seeing any other fossils associated with it. In his opinion the 'Vanuxemi Bed' forms part of the Shap–Ravenstonedale Limestone, probably near the top. He has, however, seen no trace of *A. Vanuxemi*

[1] This and several others were kindly identified by Dr. T. F. Sibly, F.G.S.

in the quarry at Shap summit, near the Granite works, which is said to be the same Limestone, though there are frequent vegetable remains (*Stigmaria*, etc.) in that quarry.

Professor Garwood, in his provisional correlation of the Faunal Succession in the Carboniferous Limestone of these Northern exposures,[1] places the Meathop Fell Beds doubtfully in C_1, and correlates them with similar dolomitic beds at Crag Mollet in the Brigsteer section. At the latter place a bed occurs at the base which is marked by clusters of *Diphyphyllum pseudo-vermiculare* (M'Coy). This same form also occurs abundantly near the top of the Shap–Ravenstonedale Limestone, so that the beds containing *A. Vanuxemi* at Shap are, in all probability, equivalent to the 'Vanuxemi Beds' at Meathop Fell.

Professor Garwood further remarks on the possibility of the above Diphyphyllid *Lithostrotion* being considered typical of (S), in which case the Meathop Fell Beds, and others, would have to be included in (S) also.

The discovery, therefore, of *A. Vanuxemi* at Meathop Fell, coupled with its occurrence in beds of, presumably, the same age at Shap, may be helpful in arriving at a satisfactory conclusion as to the correct horizon of these beds, especially when the exact horizon of the plant is known in the North Wales exposure.

In conclusion, I must express my indebtedness to Mr. J. T. Stobbs, F.G.S., and Dr. T. F. Sibly, F.G.S., etc., for their kindness in confirming the identification of several specimens, and to Dr. R. Kidston, F.R.S., etc., for kindly looking over the plant-remains and giving me his opinion thereon.

NOTICES OF MEMOIRS.

Note on the Spontaneous Luminosity of a Uranium Mineral.[2]

By the Hon. R. J. Strutt, M.A., F.R.S., Professor of Physics, Imperial College of Science, South Kensington.

RUMOURS of luminosity having been observed in Cornish minerals, in the dark, are not infrequent. I have myself been told of such phenomena by rustics in the mining district, and more than one correspondent has mentioned something similar.

Mr. F. W. Rudler[3] has quoted a remark by the late Mr. Garby that specimens of uranite "when first discovered by the miners in Huel Buller and Huel Basset were very phosphorescent, so much so that after the lights were extinguished many of the crystals might be discovered in situ",[4] and he has suggested that this may be in some way connected with the self-luminosity of radio-active bodies. The observation would seem to have been made by the miners, not by a scientific observer, and it is implied that the luminosity was of the nature of ordinary phosphorescence, and due to previous exposure to light.

[1] Geol. Mag., 1907, p. 70.
[2] Proc. Roy. Soc., Series A, 1909, vol. lxxxiii, p. 70. (Abridged.)
[3] *Handbook to Minerals of the British Islands*, published by the Geological Survey.
[4] Trans. Roy. Geol. Soc. Cornwall, 1865, vol. vii, p. 86.

Recently examining a specimen of uranite (autunite), I was struck by its resemblance to the artificially prepared uranium salts, and it occurred to me that in all probability it would be found to exhibit the spontaneous luminosity observed in these by H. Becquerel,[1] which is attributable to fluorescence of the substance under the action of its own radio-activity. Experiment confirmed this anticipation. The mineral is easily perceived in a perfectly dark room by a well-rested eye. There is no difficulty in walking up to it from a distance and touching it, without any other guidance than the luminosity. Autunite is more luminous than uranium nitrate, but less so than potassium uranyl sulphate.

This effect is quite independent of the previous exposure to light. Such exposure only leaves an afterglow in uranium salts of very short duration. It cannot be detected without the phosphoroscope.

The specimens in which I have observed the luminosity are some recently raised in Portugal, which I owe to the kindness of Mr. A. de Vere Hunt. Old specimens from Cornwall and from Autun do not exhibit it. The loss of luminosity is connected with a loss of water of crystallization. This was established experimentally by sealing up a specimen in an exhausted glass tube with phosphoric anhydride. In a few hours the latter had deliquesced considerably, while the autunite had lost both its luminosity in the dark, and also the green fluorescent shimmer which it had previously exhibited in daylight. Some uranium salts are known to be much more fluorescent than others, and there is nothing specially surprising in the fact that a loss of water is accompanied by a loss of brilliancy.

REVIEWS.

I.—Geological Survey of Great Britain.

The Geology of the Country around Basingstoke. By H. J. Osborne White, F.G.S. pp. v, 119, with 14 text-illustrations. 1909. Price 2*s*. Colour-printed map, Sheet 284, 1*s*. 6*d*.

Although not officially connected with the Geological Survey, Mr. Osborne White has already rendered much service to the Institution in writing the Memoir on the Geology of Hungerford and Newbury, and in assisting with those on Andover, Henley-on-Thames, and Wallingford. He has now written the memoir to accompany Sheet 284 of the new series Geological Survey Map, which embraces an area concerning which we have hitherto had very little detailed information beyond that contained in previous official memoirs on more extensive tracts, by H. W. Bristow, W. Whitaker, and A. J. Jukes-Browne. The six-inch field-maps, showing the revised geology, with notes by the late J. H. Blake and Messrs. C. E. Hawkins and F. J. Bennett, were placed at the service of the author.

The country under consideration is almost wholly in Hampshire, the northern part including a tract of the Eocene strata of the London Basin; and the southern part consisting mainly of Chalk with a portion

[1] *Comptes Rendus*, 1904, vol. 138, p. 184.

of the Upper Greensand inlier of Kingsclere on the west, and a portion of the Wealden area on the south-east. This latter tract, drained by the head-waters of the Wey, takes in less than a square mile of the parish of Farnham in Surrey.

The lowest formation exposed is the Gault, and the Folkestone Beds of the Lower Greensand have probably been reached in a well in the Wey Valley. The Gault, no doubt, underlies the whole of the area, but nothing is known of the underground disposition of the strata beneath, nor of the depth to the Palæozoic floor.

Particulars are given of the Gault, with the zone of *Douvilleiceras mammillatum* at its base, and that of *Hoplites interruptus* above; and also of its fossils and phosphatic nodules. The Upper Greensand, consisting largely of malmstone, siliceous and calcareous, belongs to the zone of *Schloenbachia rostrata*, and the highest beds adjoining the Chloritic Marl are locally impregnated with phosphatic matter. The phosphatic beds at the base of the Chalk, which contribute so much to the fertility of the soil on the Chloritic Marl, were described more than sixty years ago by Paine & Way, but the pits which yielded many fossils in the parishes of Bentley and Farnham have long been filled up and obliterated. The Chalk divisions range from the zone of *Schloenbachia varians* to that of *Marsupites testudinarius*, and much new information is given regarding the strata and their fossils, including the sub-zone of *Heteroceras reussianum* and the *Uintacrinus* Band.

Despite the great unconformity between Chalk and Reading Beds no evidence of discordance has been observed in the district. The surface of the Chalk was even where the junction of the formations could be seen, but in two localities the perforations of some boring animal were seen on the Chalk floor. The author assigns to the Reading Beds the blocks of greywether sandstone which occur here and there in the district.

The London Clay, which extends over a considerable area, has yielded a good many fossils, and it attains a thickness of 335 feet near Odiham. The author remarks that it is probably not more than half that thickness in the north-western part of the district. Westwards, in the Andover country, the thickness of the London Clay has been estimated at from 60 to 100 feet, while south of Newbury it is about 60 feet, and thence it diminishes further west and to the north.

The Bagshot Series is described under the headings of Lower Bagshot Beds, Bracklesham Beds, and Upper Bagshot Beds—perhaps because this classification was adopted on the colour-printed map which, though issued in 1905, was based on the hand-coloured map of 1897. The grouping, therefore, differs from that adopted in the Andover Memoir of 1908, wherein the term Bagshot Beds is restricted to the Lower Bagshot Beds. The Upper Bagshot Sands of the London Basin are now usually grouped with the Barton Beds.

There is an interesting chapter on the tectonic structure and drainage features, illustrated by a map showing the lines of anticline and syncline, while the author points out the relations of the streams to the geological structure.

The Plateau gravels are regarded as of fluviatile origin, and as "remnants of old alluvial flats or flood-plains, developed during pauses in the downward displacement of the local limit of subaerial degradation".

The Clay-with-flints, the Valley gravels, and Alluvial deposits are duly described, and there is an excellent chapter on Economic Geology.

The Memoir throughout bears evidence of much diligent research, and adds largely to our knowledge. The author, moreover, has carefully studied the works of other geologists, and does full justice to their labours. The only misprint we notice is H. W. Fitton for W. H. Fitton.

II.—THE GEOLOGY OF THE COUNTRY AROUND BODMIN AND ST. AUSTELL. By W. A. E. USSHER, G. BARROW, and D. A. MACALISTER, with Notes on the Petrology of the Igneous Rocks by Dr. J. S. FLETT. 8vo; pp. vi, 201, with 3 plates and 34 text-illustrations. London, 1909. Price 4*s.*

THIS Memoir is descriptive of the one-inch colour-printed map Sheet 347, which takes in the area from Bodmin on the north to the coast at Fowey and St. Austell Bay on the south. The greater portion of this country is occupied by Lower Devonian rocks and the bold granite mass of St. Austell and Hensbarrow, with a tract of Middle Devonian slates on the north-east. The oldest Devonian rocks, grouped as Dartmouth Slates, contain fish-remains of Lower Old Red Sandstone type, and the rocks appear in an anticline along the eastern coast to the north of Fowey, and thence extend to near Lostwithiel. They are bordered by the Meadfoot Beds, beyond which are the Staddon and Grampound Grits. The coloration of the map suggests that the Staddon Grit on the north and the Grampound Grit on the south are equivalent strata on the opposite sides of the anticline. This view is supported by Mr. C. Reid, but is not accepted by Mr. Ussher, who regards the Grampound Grit Series as representing the marginal conditions of lower beds in the Meadfoot Group, perhaps equivalent to the Looe Grits. The Meadfoot Beds have yielded a number of fossils, but so poorly preserved that most of the species and many of the genera collected by the Geological Survey are doubtfully identified. Fossils throw no light on the disputed succession, as none are recorded from the Grampound or Staddon Grits.

The Middle Devonian slates are stated to be fossiliferous, though "it is very seldom that anything but crinoid markings can be distinguished".

The region therefrom is not one to attract the student of Devonian palæontology; but a great step in advance over the older map has been made in the insertion of the geological subdivisions now depicted, while the long experience gained by Mr. Ussher has enabled him to correlate them with the subdivisions which he has traced step by step from Eastern Devonshire.

The granite areas have been mapped out in much more detail than in the original geological survey map, and the metamorphic aureole in the bordering Devonian rocks, described mainly by Mr. Barrow and Dr. Flett, has been more definitely indicated. Dr. Flett has dealt generally with the pneumatolytic alteration of the granite, observing that the changes produced by vapours passing through the rock, after-its consolidation, are of three sorts: (1) tourmalinization, as exemplified in luxulyanite and in the schorl-rock of Roche; (2) greisening, as seen at Criggan; and (3) kaolinization. The kaolinization or alteration of granite to china-stone and china-clay is a subject discussed by Mr. MacAlister, supplemented by observations made by Dr. Flett. With regard to the kaolinization, Mr. MacAlister refers to the agency of magmatic waters containing carbon dioxide in solution and fluoride vapours. Dr. Flett remarks that the facts "point to the probability that neither fluoric nor boric gases were the chief agencies of kaolinisation, and support Vogt's hypothesis that carbonic acid was the principal, though probably not the only, gas involved". Many interesting particulars are given of the china-stone and china-clay, but it has not been found possible to mark on the map the areas over which they are exposed. Economic geology, indeed, receives ample treatment. The chapter on mining, prepared by Mr. MacAlister, with numerous illustrative sections, contains full information of the workings for tin and copper ores, as well as silver-lead ores, red and brown hæmatites (for which Restormel was once famous), manganese ore, gold, uranium ore, etc. Of road-metals, the harder diabases and the calc-flintas (altered calcareous sediments in the Meadfoot Beds) are reckoned more durable than the elvans.

Mr. Barrow has described some of the physical features and the indications he has found of the old Pliocene platform at about 430 feet above sea-level. There on flat moors, beneath peat, rainwash, and head, occur ferruginous gravels that have been worked for stream-tin, and these may possibly be of Pliocene age. The later Pleistocene and Recent deposits are described in detail, evidently by Mr. Ussher, but curiously enough his initials, appended to many paragraphs, have been omitted from this section as well as from the important chapters on the Devonian rocks. This is much to be regretted.

III.—The German South Polar Expedition, 1901–1903. Vol. II, Heft V: Geography and Geology. pp. 63 and 3 plates. Berlin, 1909. Price 10 marks (8 marks to subscribers).

(Deutsche Südpolar-expedition, 1901–1903, im Auftrage des Innern herausgegeben von E. von Drygalski, Leiter der Expedition. II Bd. Geographie und Geologie, Heft V.)

THE present report is composed of four sections, dealing mainly with the islands of St. Paul and New Amsterdam in the Indian Ocean. The geography is dealt with by E. von Drygalski, the leader of the expedition, the geology by E. Philippi, the character of the rocks by R. Reinisch, and the plants and animals by E. Vanhöffen. According to Dr. von Drygalski, the islands of St. Paul and New Amsterdam are both volcanic and rest upon a common tapering base, which rises from about 3000 metres below sea-level. At a depth of 1500 metres this common source divides into two cones, which form the two islands. Both islands have a number of parasitic cones, but these do not constitute so striking a feature in the case of St. Paul as in New Amsterdam. The islands of Kerguelen and Heard on the one hand, and St. Paul and New Amsterdam on the other, also have a common base, which rises above the surrounding Kerguelen Plateau. When St. Paul, in particular, is considered it is found that the inner part of the crater is connected with the outer sea by reason of the submergence of the north-easterly part of the island along a S.E.–N.W. line. The salinity of the water within the crater basin is almost identical with that of the surrounding sea, while within the crater itself this salt-percentage, as well as the temperature of the water, remains constant for the whole depth. According to Vélain, a former explorer, the amount of carbon dioxide in the crater water increases with the depth. He derives the gas from the exhalation of CO_2 and N from the ground of the basin. Such an exhalation would also materially affect the distribution of the organic life. Former investigators have reported that the water temperature at the margin of the basin locally exceeded that of the inner portion by 4° or 5°, but this has been found by the present explorers to be not the case. Practically the same temperature prevails on the margin as in the middle. From this, as well as from other evidence of a negative kind, the absence of hot springs might be inferred. As the distance apart of the positions where the temperatures were taken is, however, about 400 metres, the existence of such springs is not an impossibility. Both islands have very steep coasts, the coast being highest on the west, where, on account of the stronger westerly winds, the wave action is heaviest. The deepest parasitic craters of St. Paul are on the south and west cape. They are already partly cut through by the sea, as shown by the charts of Vélain and von Hochstetter. Such a phenomenon shows the great influence of the wave action, since the chief crater itself, according to von Hochstetter, is not very old, and the parasitic craters are quite young. In view of the morphological and climatic conditions the only possibility of anchoring for the purpose of landing on either of the two islands is on the north-east side. It appears that human habitation would suffer from the poor water supply, and St. Paul, in particular, would be less advantageous, because of the absence of wood. An attempt was made, through a previous expedition (that of the "Novara"), to start wood-growing, but the result has been disappointing. The fishermen have successfully grown potatoes, wheat, maize, and barley, and other grain also appear to grow well. Both islands might thus be possibly used as settlements, yet the unfavourable climate and the absence of firewood would be great hindrances. The chief value of the islands lies in their wealth in fish.

In the geological section Dr. Philippi gives, as in the foregoing section, an historical account of the works of previous investigators as far as they bore on geology. Among these writers Vélain and von Hochstetter are to be particularly mentioned. Dr. Philippi differs from the older explorers in regard to the last period of eruption and the origin of the present crater of St. Paul. In agreement with von Hochstetter, he would consider the crater-opening to have been formerly much smaller and higher than the present central crater; but Dr. Philippi thinks that this older vanished central crater of the basaltic period did not lie at the middle, but near the margin of the present crater basin. Although, as stated by von Hochstetter, the present crater is a product of a very late time, and was certainly not in existence in its present form during the basaltic eruptive period, yet it is believed that the shape of the present crater is to be explained through an explosive outburst rather than subsidence. As regards the lavas and tuffs of St. Paul, it is impossible to speak of the period of their origin with certainty, because of the absence of any fossil-bearing sediments. Probably a part of the eruptive period belongs to Tertiary, another to Quaternary and later times. It is impossible, however, to know where the Tertiary portion ends and the other begins. An examination of the Dumas crater of New Amsterdam revealed evidences sufficient to support Vélain's results in all essential details. The crater cone and the lava streams which ran from it have quite a fresh appearance; the eruptions were undoubtedly still in progress during historical times. The late period of eruption of the lava streams accounts for the favourable landing facilities near the Dumas crater, for the wave action has not had time to cut a steep wall in the lava. Lateritic weathering products, which play such an important part on the island of St. Paul, are absent. This fact also speaks for the recency of eruption in the Dumas crater. In some parts of the lava, cavities, often 8 to 10 metres broad, twice the same measurement in height, and over 200 metres long, were met with. From the roofs of these caves hang lava stalactites of fantastic shapes. According to Vélain the cavities are due to gases which collected under the lava stream and afterwards forced their way through it. The present-day vulcanologist generally explains such a phenomenon as the result of the coating of the upper layer of the lava stream by a non-yielding outer crust; the inner portion of the stream, moving forwards, would leave behind a hollow cavity. Some of the cavities observed by the present expedition were undoubtedly the result of gaseous accumulation.

Dr. Reinisch discusses the chemical relationship of the basalts of St. Paul, New Amsterdam, Kerguelen, Heard, and Possession Islands. Rhyolite tuff, basalts, and siliceous sinter are found on St. Paul; only basalts of various constitution are known on New Amsterdam, basalts, phonolite, and trachyte on Kerguelen, and basalts on Heard and Possession Islands. Very instructive tables and diagrammatic proportional representations of the chemical constituents of the rocks are given.

Dr. Vanhöffen treats of the plants and animals of St. Paul and New Amsterdam in an exhaustive manner. A comparison of the faunal lists of the two islands shows a certain agreement. This agreement would probably be found on closer investigation to be still greater than appears at present. It is also seen that the number of peculiar forms is few and that no close relationship exists with the animal life of the neighbouring sub-Antarctic islands. Hence it is inferred that the fauna is an accidental and not an original one, and that it has been affected by human interference.

The report is illustrated by three plates of eight photographic views and several text-illustrations.

Ivor Thomas.

IV.—Aids in Practical Geology. By Professor Grenville A. J. Cole. Sixth edition. 8vo; pp. xvi, 431, with 2 plates and 136 text-illustrations. London: Charles Griffin & Co., 1909. Price 10*s.* 6*d.*

THAT a geological handbook should pass through six editions in the course of eight years is the most satisfactory testimony to its merits, and we heartily congratulate the author on the well-deserved success of his work. The volume has remained of the same dimensions since we noticed the issue of the fourth edition in 1902, but it has undergone sundry revisions and alterations needful to bring the subject-matter up to date. As a companion and practical guide to geology the work is excellent. In the preliminary chapters the student will learn how to equip himself for field observations and the collection of specimens, while the main portions of the volume give precise and abundant information on the modes of examination and determination of minerals, and of rocks, sedimentary, igneous, and metamorphic. The final part deals with the examination of fossils, so far as the invertebrata are concerned, and the author has rightly endeavoured to keep the limits of the genera as wide as possible. Thus we are glad to see such a name as *Rhynchonella spinosa* perpetuated in place of the modern subdivisions of the genus, which are useful only to a palæo-zoologist.

V.—Transactions of the New Zealand Institute, vol. xli, for 1908, issued June, 1909.

IN an article on "The Geology of the Quartz Veins of the Otago Goldfields", Mr. A. M. Finlayson points out that these veins would suffice to account for the alluvial gold, and that no other source, such as had been suggested with reference to the schists, supplied any appreciable quantity.

Dr. P. Marshall describes a nephelinitoid phonolite from Rarotonga, and a similar rock has been found near Signal Hill, Dunedin, by Mr. C. A. Cotton, who gives an account of other varieties of phonolite from that district. Mr. R. Speight records the occurrence of a hornblende-andesite in the Solander Islands. Dr. Marshall describes some new species of fossil Cephalopods from strata in the neighbourhood of Mandeville and Kawhia Harbour. They include *Broncoceras*, *Orthoceras*, *Arcestes*, *Phylloceras*, and *Ægoceras*. Among other fossils are *Ostrea*, *Gryphæa*, *Trigonia*, *Halobia*, and *Spiriferina*. Dr. Marshall remarks: "Since several of these are not known in strata older than the Jurassic, it is probably right to class these strata as Jurassic, thereby ignoring the presence of the archaic genera here mentioned. This conclusion seems all the more reasonable when the present isolated position of the Dominion is considered. It is quite possible that another period of isolation had terminated at the beginning of the Jurassic period. An old fauna which had lived on during the period of isolation would then be mingled with the invading newer and more vigorous types. Such an explanation might reasonably account for the rapid change in life-forms which has caused Sir James Hector to class a conformable series of rocks as of an age extending from Permian to Jurassic."

VI.—Geological Survey of Western Australia.

BULLETIN No. 35 (1909) consists of a well-illustrated report on the Gold and Copper Deposits of the Phillips River Goldfield, by Mr. Harry P. Woodward, with notes on the crystalline rocks by Messrs. E. S. Simpson and L. Glauert. The district lies near the south coast, with a port about 150 miles east of Albany, and in geological structure it is a complex of schists and serpentines, granites and greenstones, together with some probably Tertiary sandstones, quartzites, and conglomerates, and various superficial deposits. The crystalline rocks are much decomposed, in places to a depth of nearly 100 feet, and the lodes, with few exceptions, have at present been worked only above the ground water-level. The lodes comprise (1) basic cupriferous dykes, and (2) siliceous and ferruginous deposits, which appear to fill channels along rock-joints. The conclusions drawn are that the cupriferous dykes are of sufficient size to warrant deep mining, but that gold and silver will then occur in negligible quantities. The siliceous and ferruginous deposits give less promise of permanency, but they usually carry fairly high gold and silver values, and have been classed as auriferous lodes, copper, when present, being in small quantities. In some instances, however, with increasing depth, the gold is greatly diminished, and copper ore becomes dominant. It is noted that primary sulphides occur in the rocks above the ground water-level, and the explanation given is that the great density and impermeable character of the matrix have protected the ore, in these cases, from the oxidizing influence of descending aerated water. The ores worked during the past eight years have yielded on an average 4 per cent. of copper and half an ounce to the ton of gold.

VII.—Schluchten auf dem Plateau Tschokusu. By Alexander Iwtschenko (of Kiev). [The Ravines of the Tschokusu Plateau.] Ann. géol. et minéral. de la Russie, Novo-Aleksandria, vol. xii, livr. i–ii, pp. 19–26.

THIS paper sets forth the results of the investigations carried out by the author during a second excursion to the southern portion of the Tschokusu Plateau in the summer of 1908. The district is cut out into terraces, the southern margins of which are broken into by ravines. These ravines widen considerably, and often form cauldron-shaped expansions in their upper reaches (*Oberläufe*), while the lower reaches become narrower. The terraces undoubtedly represent the results of the drying-up of the Aral basin. Their relative size and slope point to intermittent recession of the sea, the periods of non-recession corresponding to the time when the terraces were formed. The ravines were formed contemporaneously with the recession of the sea, the upper reaches having originated at an earlier period than the narrower lower reaches. From the nature of the denudation the Tschokusu Plateau belongs to the same category as the district of Barsukow; both are characterized by desert conditions.

The article is accompanied by three photographs and two diagrammatic illustrations.

I. T.

VIII.—A New Pocket-Guide to Chalk Fossils. Karl Wanderer. Die wichtigsten Tierversteinerungen aus der Kreide des Königreiches Sachsen. 8vo; pp. xxii, 80, with 12 plates in 4to (folded), and 11 figures in the text. Jena, 1909. Price 3 marks.

The plan of this little book is excellent. It provides a tabular view of the Chalk of Saxony, a bibliography, a list of places where fossils can be obtained, and devotes its eighty pages to short descriptions of the fossils, commencing with the Foraminifera and ending with the Vertebrata, completing the whole with an alphabetical index to the fossils. The text-figures are explanatory diagrams of the structural features of regular and irregular Echinoderms, Brachiopods, Pelecypods, Gasteropods, and Cephalopods, and the plates provide sufficiently good figures of all the fossils described in the text. The book is cut to a convenient size for the pocket, and provides the worker in the field with a handy means of readily identifying the bulk of his finds on the spot. The English collector will find this book of considerable value for his own purposes.

C. D. S.

IX.—The Ore Deposits of South Africa. Part I: Base Metals (1908). Part II: The Witwatersrand and Pilgrimsrest Goldfields and similar occurrences. By T. P. Johnson. London: Crosby Lockwood & Son, 1909. Price 5*s.* net each.

These two small volumes are intended for the use of those technically connected with the mining industry and as a guide to the prospector.

In a country of such diversified geological structure as South Africa it is difficult to gauge the wants of those interested in the development of its mineral resources; but it may be as well, and sufficient, to state that the author ignores the stratigraphy of the country, since, in his opinion, the "principles of ore deposition" are independent of it.

Considering the high price and small size of these volumes we should have expected to find more original subject-matter, more carefully prepared maps and sections, and a greater economy of space both in the arrangement of the text and of the sections.

X.—Brief Notices.

1. Journal of Geology (Chicago).—In this Journal for October–November, 1909, there is an interesting article on the "Physical Geography of the Pleistocene, with special reference to Pleistocene Conditions", by Mr. R. D. Salisbury. He refers to evidence of greater depression during the glacial epochs than during the interglacial; also to the effect of increase of altitude on climate, leading to greater erosion and to the greater consumption of carbon dioxide whereby the temperature became lowered. Decay of rocks was checked by decrease of altitude or temperature, or by the accumulation of ice-sheets which protected the rock beneath from ready carbonation. The author refers also to the loading of the land-surface with ice over vast areas, to the consequent effect on crustal movement, and to the recurrent processes

of erosion and sedimentation by ice agencies. Finally he deals briefly with changes in life, which apart from mammals have been insignificant, observing that even among mammals it is not clear that the dying-out of species in one locality was contemporaneous with the disappearance of the same species in other localities.

Mr. Stuart Weller contributes the "Description of a Permian Crinoid Fauna from Texas", and Mr. S. W. Williston gives an account of "New or little-known Permian Vertebrates", with the description of a new genus of amphibian, named *Trematops Milleri*.

2. Philippine Islands.—Dr. Warren D. Smith has issued a report on *The Mineral Resources of the Philippine Islands* (Bureau of Science, Manila, 1909). He regards the future results of mining as promising. The gold production from lodes, decomposed rocks, and placer deposits rose in value from about £20,000 in 1907 to £50,000 in 1908. Coal, worked on Batan Island, amounts to 130 tons a day. There is a good deal of iron-ore, but at present there is only one furnace in operation, and this is owned and worked by a Filipina woman. Limestone and shale suitable for cement occur; and there are indications of petroleum, kaolin, manganese ore, and copper. Artesian water has been obtained in the great plain of Luzon.

3. Geological Survey of Canada.—Among publications issued in 1909 by the Canadian Department of Mines, we have received a report by Mr. D. B. Dowling on *The Coal-fields of Manitoba, Saskatchewan, Alberta, and Eastern British Columbia.* The coal is found on three distinct horizons in the Cretaceous, separated by shales of marine origin. The lowest horizon is at the base of the system, and is considered to be Cretaceous from its flora. It lies just above the Fernie Shale, which is regarded as Jurassic. The coals include anthracite, bituminous coal, and lignite, and the author estimates that there is a total quantity of more than 143 thousand million tons in the provinces described.

In another report Mr. R. G. McConnell describes "The Whitehorse Copper Belt, Yukon Territory". The belt, as at present determined, extends for a distance of about 12 miles, and the principal ore bodies occur in limestone adjoining granite. The important economic minerals are the copper sulphides, bornite, and chalcopyrite; and they are associated in some cases with magnetite and hæmatite, in other cases with garnet, augite, and tremolite.

We have also received a useful *Catalogue of Publications of the Geological Survey, Canada,* revised to January 1, 1909.

4. Mining Magazine.—We have received a copy of the *Mining Magazine* for November, 1909, being No. 3 of vol. i. Although it deals essentially with the practical applications of geology, with mining and metallurgy, with companies, investments and speculations, and with problems of labour, it also contains reviews of books, and many miscellaneous paragraphs of scientific as well as economic interest. Some remarks are made on the British Radium Corporation, formed to work the pitchblende in the Trenwith Mine in Cornwall, and doubt is expressed whether it is a sound commercial undertaking.

There is an article by Mr. T. T. Read on "Coal Mining in Manchuria". The Fushun Mines, north-east of Mukden, are worked in Tertiary strata, which yield a soft bituminous coal. The total thickness of coal varies from about 150 to 270 feet, made up apparently of many seams closely associated. The greatest thickness without a parting is 32 feet, but the five seams worked are each from 9 to 12 feet thick. It is estimated that the production for 1909 may be about 700,000 tons. Apparently the coal was worked in very early times for the manufacture of pottery, as in making excavations on the ground large quantities of ancient Korean pottery and coins dating back to 300 B.C. have been discovered.

5. Geology of Bristol.—A concise and interesting *Sketch of the Geological History of the Bristol District*, by Professors C. Lloyd Morgan and S. H. Reynolds, has been published by the Bristol Naturalists' Society (Proceedings, vol. ii, pt. ii, 1909). It contains references to the principal published works, and embodies accounts of the more recent researches on the Silurian rocks, the Carboniferous zones, and the origin of the physical features.

6. Geological Survey of New Jersey.—The Annual Report of the State Geologist, Mr. H. B. Kümmel, for the year 1908 (1909), contains an account of the zinc mines of Sussex County, by Mr. A. C. Spencer. The ore minerals are principally franklinite, containing oxides of iron, manganese, and zinc; willemite, silicate of zinc, much of it containing manganese; and zincite, oxide of zinc, also with manganese. Mr. J. V. Lewis contributes a report on the Building Stones, illustrated with map, views of old and new buildings, and coloured plates of various granites, serpentine, marble, and other rocks.

7. Geological Literature added to the Geological Society's Library during the year ended December, 1908. 8vo. London (Geol. Soc.), November, 1909. Price 2*s.*—It is merely necessary to remind our readers that this valuable record of the geological work of the world is published for 1908. Mr. W. Rupert Jones, Mr. Belinfante, and Mr. C. H. Black have all contributed to the heavy task of getting it ready, and the publication fully maintains its position as the one indispensable work of reference for all geologists. An index of 76 pages to 113 pages of bibliography sufficiently indicates the exhaustive nature of the work and its utility.

REPORTS AND PROCEEDINGS.

Geological Society of London.

December 15, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Skiddaw Granite and its Metamorphism." By Robert Heron Rastall, M.A., F.G.S.

The visible exposures of the Skiddaw Granite are three in number, all very similar; part of the more northerly one is a greisen, which is not here dealt with. The normal granite is more or less porphyritic in structure, with large phenocrysts of perthite, in a coarse or fine-textured ground-mass of orthoclase, plagioclase, biotite, and muscovite. Various micrographic intergrowths occur, indicating in some cases eutectics of three or more components. No reliable analyses are available, but the rock is provisionally classed as an alkali-granite of Hatch's classification.

Evidence is brought forward to indicate that the granite is intruded along the axis of an anticline, with a strike approximately E. 15° N. and W. 15° S., the normal direction for the district.

The metamorphic aureole is very large, measuring about 6 miles from east to west and 5 miles from north to south. This is out of all proportion to the size of the visible exposures of granite, and it is inferred that the intrusion underlies a large area at a small depth.

Within this area three distinct rock-types can be recognized, namely, (1) black slates, (2) grey flags, (3) grey grits. The metamorphism produced in each of these is described in detail, and it is shown that the commonly accepted zones of alteration do not hold, since the rocks concerned were originally of very different character. The frequently described section in the Glenderaterra Valley runs across the strike, and includes both black slates and grey flags. The former never undergo a high degree of metamorphism, chiastolite being the characteristic mineral. The well-known cordierite-mica rocks of Sinen Gill are derived from the grey flags, and a very narrow zone close to the granite shows garnet and staurolite. The impure grey grits of the central band contain cordierite, andalusite, and mica, and garnets are only seen close to the contact with the Grainsgill greisen. The Carrock Fell intrusion produces little or no alteration in the grits, with which it comes into contact for a long distance.

The phenomena here displayed may be summed up as an example of a moderate degree of thermal metamorphism, due to the intrusion of a large mass of granite, at a comparatively low temperature, into a series of rocks of variable composition, which had previously undergone dynamic metamorphism. The most important minerals produced are cordierite, andalusite and chiastolite, biotite and muscovite, while garnet and staurolite are only found close to the granite. Owing to the variations of lithological composition across the strike, it has not been found practicable to divide the aureole into concentric zones, but the alteration is gradual and progressive towards the intrusion.

2. "The Metallogeny of the British Isles." By Alexander Moncrieff Finlayson, M.Sc., A.O.S.M., F.G.S.

The ore-deposits of the British Isles (tin, copper, lead, zinc, gold) are considered synthetically in their relation to igneous rocks and to tectonics. The four major epochs of igneous activity and crust-movement in the area were: pre-Cambrian, post-Silurian (Caledonian), post-Carboniferous (Hercynian), and Tertiary. A few insignificant ore-occurrences, including the stanniferous magnetite in the older granite-gneiss of Ross-shire, date from the pre-Cambrian. A group of pyritic fahlbands in the Highlands of Scotland, and the wolfram-bearing pegmatites of the Grainsgill greisen, date from the Caledonian, accompanying the widespread province of Caledonian granites. The great bulk of the deposits of economic importance, including the veins of Cornwall and Devon, the lead, zinc, and copper veins in England, Southern Scotland, Wales, and Ireland, are of Hercynian (and Armorican) age. This is shown by the age of the fissuring in many cases (post-Carboniferous to pre-Triassic), by the absence of ore-veins in Jurassic or later formations, and by other evidence. The Tertiary volcanic period was not accompanied by ore-deposition, the evidence which has been adduced in favour of this in the Isle of Man, Cornwall, and Devon, and the North of England, being unsatisfactory.

The ore-deposits are classified in accordance with the above-mentioned metallogenetic epochs, and are divided into metallogenetic provinces, as has been done by Professor L. de Launay with the ore-deposits of Italy, Africa, and Siberia. The essential features of the different groups are summed up. The evidence, collected and sifted, indicates the following zones of ore-deposition :—

(1) Pneumatolytic zone: tin, passing up into copper.
(2) Deeper vein-zone: copper with gold. Lead and zinc subordinate.
(3) Middle and upper vein-zones: lead and zinc. Copper subordinate.

The conclusions drawn from the investigations are :—

(i) The importance of the physical conditions of the Permo-Trias in favouring ore-deposition in upper zones.

(ii) The close connexion between metallogenetic and petrographical provinces, and the essential dependence of ore-formation throughout geological time on the differentiation of igneous rocks accompanying great crustal movements. Differences in ore-deposits in different localities and regions appear to be due to primary differentiation of ores accompanying the differentiation of igneous magmas at successive epochs.

3. "The Geological Structure of Southern Rhodesia." By Frederic Philip Mennell, F.G.S.

The author describes in some detail a portion of what may be termed 'the Laurentian Area' of Africa. The oldest rocks include all lithological varieties, and exhibit most of the known types of alteration. They comprise a great development of hornblendic rocks (epidiorites and amphibolites); on the other hand mica-schists, and sheared rocks generally, are conspicuously absent. They include (1) 'basement schists' on which the altered sediments were laid down, and (2) altered basic igneous intrusions, simulating rocks of any previous age. All these are older than the granites by which they, and the metamorphic series, are invaded.

The vertically bedded 'ironstone series' is described, and is compared with similar rocks of the Lake Superior region. They are shown to be especially developed along the eastern border of Matabeleland, and their conspicuous banding is attributed to re-crystallization of fine mechanical sediments under pressure.

The conglomerate beds (or Rhodesian 'Banket') are 10,000 feet thick, and rest unconformably upon the ironstone series in the west, both these formations being gold-bearing. But they overlap also elsewhere on to the 'basement series'; while they are represented apparently in North Mashonaland by a thick series of grits, resembling microscopically the Moine Gneisses of the Scottish Highlands. The series contains pebbles of granite free from microcline, and banded ironstones.

The thick crystalline limestones overlying the conglomerate series contain chert and dolomite, the latter rock occurring also as an alteration product from serpentine. Graphite also is found, and is attributed to the insolubility of carbonaceous matter in a highly siliceous magma. Contact alterations of the limestones by the granites are described.

The granites occupy the greater part of the area dealt with, and their intrusive character as regards the metamorphic rocks is shown. The normal granites are biotite-bearing, and have microcline as the dominant felspar; they never contain hornblende or muscovite. Patches of micropegmatite are included in the microcline, proving that the 'eutectic' was not the final residuum of crystallization. Orthite, as well as epidote, occur in most sections cut from the Matopo Granite, and the author compares the mixed rocks of the gneissose edges of the granite with the 'Fundamental Gneiss' of Canada and other regions.

The sedimentary series is subdivided as follows:—

Zambesi Basin.	*Thickness in feet.*
Taba's Induna Series	200
Forest Sandstones and Basalts	1000
Escarpment Grits	400
Upper Matobola Beds (coal-bearing)	300
Busé Beds (local only?)	300
Lower Matobola Beds (coal-bearing)	200
Sijarira Series	2000

Limpopo Basin.
- Tuli Lavas.
- Coal Beds.
- *Unconformity.*
- Samkoto Sandstones.

No fossils are recorded, other than silicified wood, except in the coal-bearing beds, in which occurs *Palæomutela Keyserlingi* of the Russian Permian, as also plants.

Various igneous rocks are described, including the great mass of picrite extending nearly across Rhodesia, which the author considers to be intrusive along a thrust-plane.

The paper concludes with a description of the diamond-bearing beds of Rhodesia, which resemble those of Kimberley, and also contain fragments of eclogite.

CORRESPONDENCE.

THE PRICE OF GEOLOGICAL SURVEY MAPS.

Sir,—A recent decision of the Treasury, that the prices charged for all Government publications should be sufficient to cover the cost of their production, is calculated to discourage the pursuit of science and to prevent the spread of knowledge obtained at great cost. One result of this decision is that the price of almost all the hand-coloured Geological Survey Maps (the vast majority of those published) has been raised, in some cases preposterously; for instance, quarter-sheet 92 N.E., Pateley Bridge, is raised in price from 3*s.* to 14*s.* 3*d.*, quarter-sheet 81 S.E., Buxton, from 3*s.* to 8*s.* 3*d.* This means that while thousands of pounds are spent in geological surveying the results are inaccessible to the public except at an almost prohibitive price. It makes British geologists envy their friends in the United States, where the antediluvian hand-colouring is unknown, and a geological folio containing topographical geological economics, and structural map with explanation, can be bought for 25 cents (1*s.*). In Canada geological survey maps are supplied gratis to Canadians. I would gladly join in a memorial, or, if necessary, a deputation to the Chancellor of the Exchequer, to obtain the reversal of this penny-wise policy.—Yours sincerely,

BERNARD HOBSON.

TAPTON ELMS, SHEFFIELD.
January 6, 1910.

MISCELLANEOUS.

GEOLOGICAL SOCIETY, 1910, MEDALS AND AWARDS.—The Council of the Geological Society have this year made the following awards: The Wollaston Medal to Professor W. B. Scott, of Princetown University; the Murchison Medal to Professor A. P. Coleman, of Toronto University; the Lyell Medal to Dr. Arthur Vaughan; the Wollaston Fund to Mr. E. B. Bailey; the Murchison Fund to Mr. J. W. Stather; and the Lyell Fund jointly to Mr. F. R. Cowper Reed and Dr. Robert Broom.

THE GEOLOGICAL SURVEY OF EGYPT.—Dr. William Fraser Hume, Assoc.R.C.S. and Assoc.R.S.M., F.G.S., who has served for more than ten years as a Geologist on the Survey of Egypt, has now been appointed Director of the Geological Survey in the Public Works Department, Giza, Egypt. He has contributed many valuable papers on Egypt to the GEOLOGICAL MAGAZINE.

ERRATA.—"Old Granites of the Transvaal and South and Central Africa," by C. B. Horwood & A. Wade. The authors request to be allowed to make the following corrections:—In Part I (October, 1909), p. 455, l. 1, for "Just over *three* years ago" read "Just over *four* years ago". On p. 458, l. 11, for "*chrom*-iron" read "*chrome*-iron". In Part III (December, 1909), p. 543, 6th line down, after "the strike" add comma. On p. 546, l. 33, for "further east" read "north-west from there". On p. 546, l. 34, delete comma after "Gordonia" and insert a comma after "generally".

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

MARCH, 1910.

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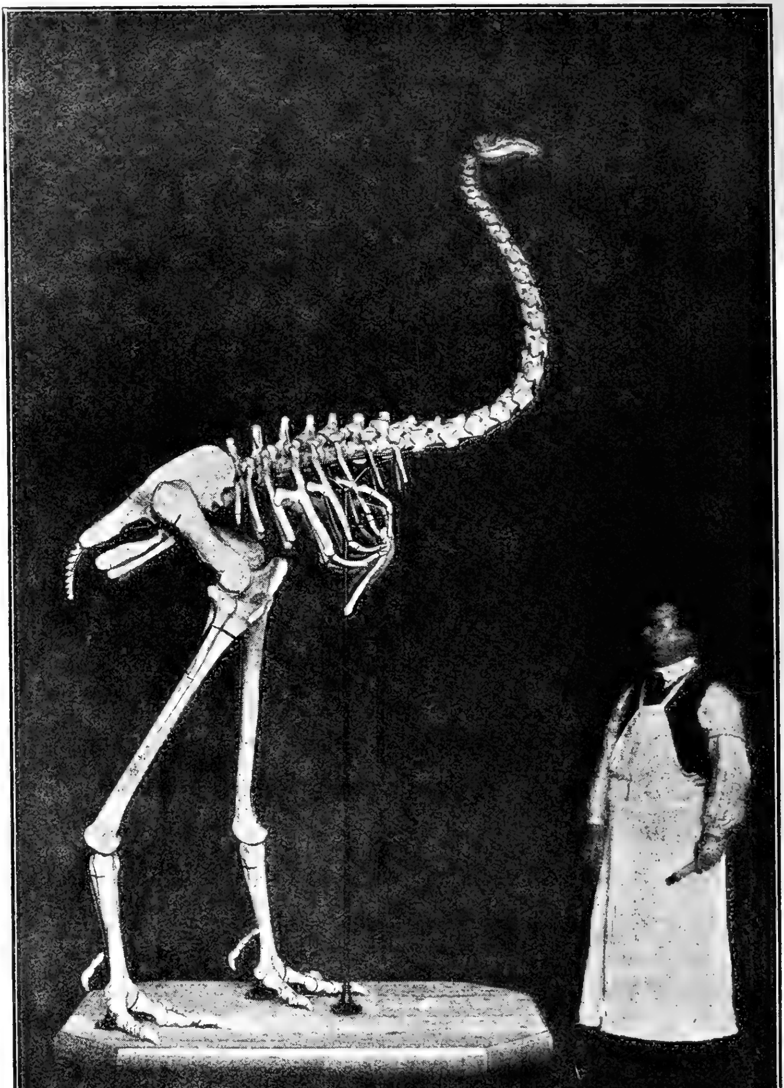


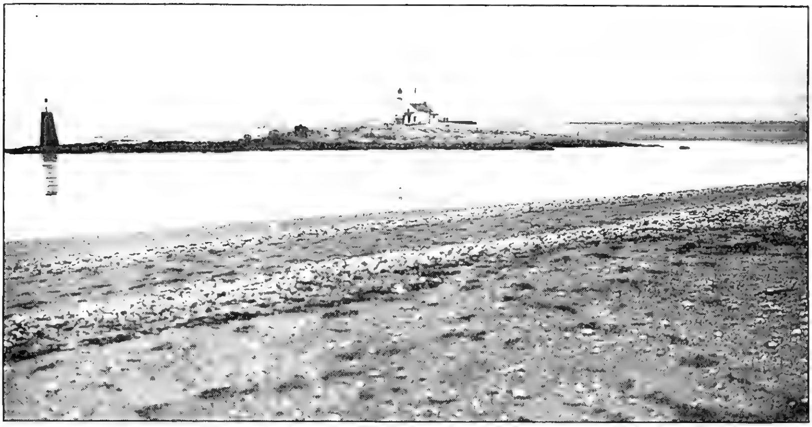
A COMPLETE REPRODUCTION OF THE SKELETON OF

DINORNIS MAXIMUS

(the gigantic 'Moa' of New Zealand) as supplied to the Natural History Museum, Brussels, by

ROBERT F. DAMON, Weymouth, England.

Height 300 cm.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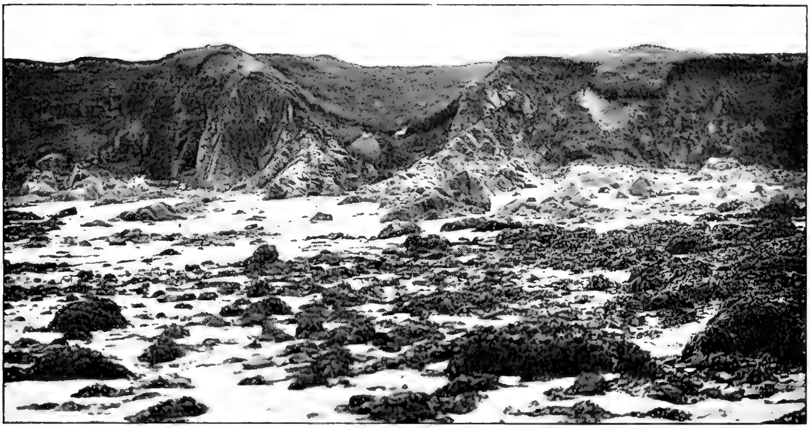
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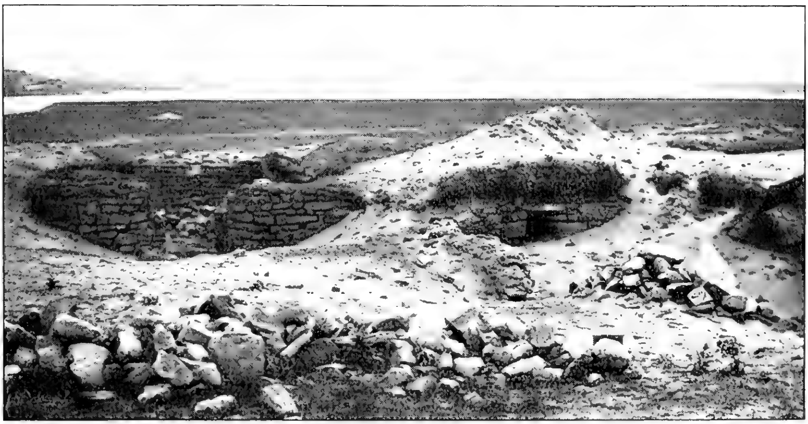
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G. Mercière photo., Auray, Brittany.

FIG. 1. Cap de Garde, Rivière d'Étel.
" 2. Cliff of 'granulite', left bank, Rivière d'Étel.
" 3. Ruins of Chapel of Ste. Brigitte, near La Magoire.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VII.

No. III.—MARCH, 1910.

ORIGINAL ARTICLES.

I.—Æolian Deposits on the Coast at Étel, Morbihan. Part II.

By the Rev. R. Ashington Bullen, B.A.Lond., F.L.S., F.G.S., etc.

(PLATES IX AND X.)

§ 1. Description of microscopic sections of pebbles forming the Raised Beach at Étel.

§ 2. Description of the photographs illustrating facts contained in Part I of this paper.

THIS brief article is necessitated by the impossibility of procuring photographs and rock sections in time for incorporation in my former paper in the January number of the Geological Magazine, pp. 6–15.

§ 1. The rocks (i) of the Raised Beach at Étel and (ii) of the local granulite (in the French sense of the word) have been submitted to Mr. Russell F. Gwinnell, B.Sc., of the Royal College of Science, South Kensington, and after having had specially thin sections of them prepared, he reports as follows:—

Petrographic Description of Rocks from Étel, Brittany, collected by the Rev. R. Ashington Bullen.

(Plate X, Figs. 1–5.)

These rocks are all quartzites, varying slightly as to accessory constituents, and differing from one another more as to the degree in which the superinduced or metamorphic structures are exhibited. Textural differences also slightly accentuate the variation in appearance. One is reminded of the schistose grits or quartz-schists of the Dalradian Series of the South-West Highlands of Scotland, but still more forcibly of the Cambrian quartzites of the North-West Highland complex.

Pl. X, Fig. 1, is a very fine-grained rock, with a foliated structure which, though quite well marked under polarized light, is not apparent in ordinary light. It consists mainly of minute elongated granules of quartz, forming a fine mosaic of interlocking individuals. Undulatory extinction indicates mechanical strain. The rock is intersected by numerous veins running in many different directions, and consisting of comparatively coarse crystals of quartz, full of minute inclusions and secondary in origin. Many minute rounded grains of an opaque black material are distributed throughout the rock, and, by their local abundance, render it opaque in patches. This material suggests carbonaceous matter, but it is impossible to definitely identify it under the microscope. Occasional small brownish patches of indefinite characters suggest a coloured mica or micaceous hæmatite.

Pl. X, Fig. 2, is much coarser in texture, the quartz-grains, which are extremely irregular in shape, varying very considerably in dimensions. The interlocking of the grains is striking, but foliation is not evident. Strain polarization effects are well shown, especially in the larger individuals. Small streaks and patches of brown material occur, as in Fig. 1, and a slight film of it envelops each quartz-grain. Minute inclusions, probably of liquid or gaseous matter, are abundant in the quartz, and in places occur in long series, continuous through adjacent crystals.

In Pl. X, Fig. 3, the foliation is again seen to be distinct, and the quartz-grains are fairly uniform in size: a sort of groundwork of smaller grains has, scattered through it, elongated crystals of much greater dimensions, but agreeing approximately in size with one another. Many of the crystals, both of the smaller and the larger size, are fairly regular in contour, being three or four times as long as they are wide. Undulatory extinction is common, inclusions are quite rare, while the brown-red indefinite staining material is very abundant, and has the characters of hæmatite in places.

Pl. X, Fig. 4, is coarser in texture than any of the others. All the grains are large and most of them elongated, so that the foliation is well seen. Inclusions are not abundant, but in places occur in series, especially along lines of apparently incipient fracture. The brown-red colouring matter is fairly abundant, and a very little mica is suggested here and there. Undulatory extinction is again noticeable.

Pl. X, Fig. 5. In structure this rock is holocrystalline, hypidiomorphic, without porphyritic constituents; its texture is of medium coarseness. The specimen is somewhat decomposed, as is shown by the partial kaolinization of felspars, while there is a decided tendency for the individual crystals to separate from one another to produce an angular sand. In mass the rock is very pale in colour, and white mica, felspar, and quartz are easily recognizable; the few dark streaky patches seen by the naked eye are found by microscopic examination to be biotite. Under the microscope *felspars* are seen to be most abundant, the other essential constituents being *quartz*, *muscovite*, and *biotite*. The two micas are, in several instances, in parallel growth, while the contours of the various crystals show that the micas have usually preceded the felspars, and the quartz has succeeded them in order of crystallization. The felspars are invariably kaolinized, but not to a great extent. In some cases an outer zone of nearly fresh felspar surrounds a kaolinized kernel. The simple twinning of *orthoclase* is seen in numerous crystals, while others are striated. Some of these *plagioclases* show simple twinning together with twinning on the albite law, while a very few exhibit the cross-hatching due to albite with pericline twinning: these latter may be considered as *microcline*. A number of observations of extinctions in plagioclases exhibiting albite twinning gave low readings (5°–12°); thus these are *oligoclase-andesine*. The quartz is clear, with a few minute inclusions, and is mostly quite allotriomorphic. The micas are abundant, well-shaped, and usually associated in parallel growth. The muscovite is quite clear and colourless, while the biotite is of a greenish-brown colour with moderately strong pleochroism: its birefringence shows that the green tint is not due to chloritization: inclusions with slight pleochroic halos are found. Accessory and secondary constituents (other than kaolin) are uncommon, a little granular epidote being alone noteworthy: this is associated with, and presumably derived from, decomposed felspars. This rock is a 'granite-proper' or 'two-mica granite', the 'muscovite-granite' of some authors, a 'granulite' in the French sense.

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§ 2. The granulite, or muscovite-biotite granite, outcrop can be seen in Fig. 1 (Plate IX). The point thus formed is the Cap de Garde at the mouth of the Rivière d'Étel, looking across westward from the left bank, at about half-flood tide. I find that the tower (La Tourelle) does not stand actually on the rock called Le Chaudronnier; the latter is seen surrounded by water a little behind and westward, and is indicated by the white arrow pointing from above it. Consequently my former remarks must be modified to this extent, other statements of fact, however, remaining unaltered.

It was in the 'baylet' just westward of the granulite that the masses of rolled peat occurred.[1] As the prevailing winds are from the south-westward, and as strong currents seem to set from westward, the source of the submerged peat beds may possibly be to the westward too. The prevailing current is said to originate in the region of westerly winds in the Atlantic, and to flow along the north coast of Spain and up the west coast of France to the north-westward, but it is much influenced by the prevailing wind and the tidal currents.

The only submerged peat beds that have been described in Brittany lie on the north coast at Plougasnel-Primel, near Morlaix (Finistère). The deposit measures roughly 7 ft. 6 in. in thickness, and contains four well-defined vegetable layers, the upper containing stools of trees (beech, holly, and hazel). There are two well-marked peat beds, the upper being ·40 metre and the lower ·55 metre in thickness (see L. Cayeux, Bibliography, *al fin.*). M. Jos. Bourlot also mentions a submerged forest (elm) at Pointe du Raz, and suggests others round the Bay of Douarnénez (see J. Bourlot, Bibliography, *al fin.*).

The lines of white quartz pebbles on the left bank are most probably derived from old Raised Beaches of Pleistocene age (now obliterated, except fragmentarily), just as the pebbles of the Chesil Beach, in Dorset, have been derived from beaches of the same age in England.[2]

Fig. 2 (Plate IX) shows the cliff (*falaise*) on the left bank, marked $\gamma, \ldots \gamma$, in the plan. The place from which the 'granulite' was procured for the microscope is marked with a white ×. The capping of the cliffs is of blown-sand, with grains of quartz and brown and white mica, and contains much finely broken debris of *Bittium reticulatum*, as well as many entire shells of the same abundant species. The sand here is of a brown colour, most probably due to this fact. This is the finest outcrop of 'granulite' between Étel and the sea. Bolder cliffs occur, however, at Pont Lorois, about

[1] Geol. Mag., No. 547, January, 1910, p. 8.

[2] Prestwich, *Geology*, vol. i, p. 99. Minutes of Proceedings of the Institute of Civil Engineers, vol. xi, pt. ii, p. 4. For summary see Damon, *Geology of Weymouth*, p. 174.

3 miles northward. The height of the cliffs at Étel is about 30 feet. The corresponding outcrop opposite, across the river, is almost planed down to the level of the shore-sand.

Fig. 3 (Plate IX) gives the scanty ruins of the chapel of Ste. Brigitte looking northward across the river to Étel itself. The stones, as can be seen, are unmortared, and the whole building is of a primitive type of construction. Many shells of *Cardium edule* occur on the east side. With this we may compare the kitchen midden surrounding Constantine Church, Cornwall, and that near St. Piran's Church, Perranzabuloe, also in Cornwall, some scanty remains of which are still in evidence.[1] The narrowness of the door, with its stone lintel, and the absence of the arch are noteworthy. The date of the building probably approximates more nearly to that of St. Piran's first church, which was completely overwhelmed by blown-sand in the seventh century A.D.,[1] than to any later date.

The views (Plate IV, Geol. Mag. for January, 1910) were adapted by Miss Gertrude M. Woodward from French views, to the unknown authors of which, and to her, my thanks are due. I am also greatly indebted to M. Charles Garnier, of Étel, for invaluable help in kindly arranging and superintending the taking of photographs of all the principal points requiring illustration, a pleasant proof of the reality of the 'Entente Cordiale'.

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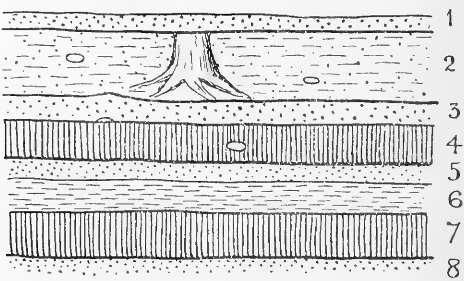
M. Cayeux gives the following section:—



1. Sable (·10 m.).
2. Sable tourbeux et tourbe avec souches (·55 m.).
3. Sable (·25 m.).
4. Tourbe banc supérieur à Roseaux (·40 m.).
5. Sable (·15 m.).
6. Tourbe (alluvion végétale) (·55 m.).
7. Tourbe, banc inférieur à Roseaux (·55 m.).
8. Sable (·10 m.).

[1] Proc. Malac. Soc., vol. viii, p. 247.

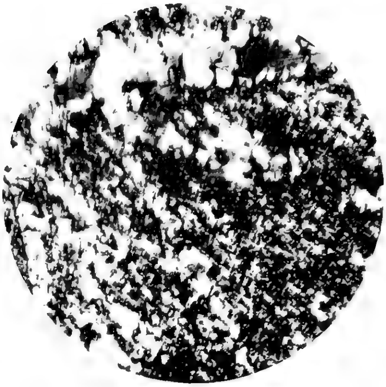


FIG. 1. X20

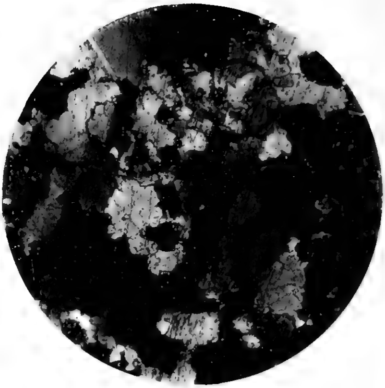


FIG. 2. X20

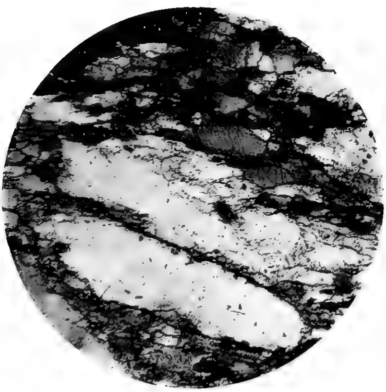


FIG. 3. X20


FIG. 4. X20


FIG. 5. X20

H.A.B. Photomicro. Bemrose, Collo.

Sections of Rocks from Étel, Brittany.

Notes.

2. Submerged forest (with tree-stumps): the soil is sandy and the vegetable matter is almost transformed into peat.
3. Gray quartz sands with traces of mica. Pebbles (rare) at base.
4. Peat (*Arundo phragmites*, L.), insect remains, elytra of Coleoptera.
5. Corresponds in material with 3.
6. Small branches of Poplar, Beech, Holly, and Hazel.
7. Peat. Insect-remains less common than in 4.

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EXPLANATION OF PLATES.

Plate IX.

Fig. 1. Cap de Garde.
,, 2. Cliff of Granulite, left bank R. d'Étel.
,, 3. Ruins of Ste. Brigitte, looking northward to Étel.

Plate X.

Sections of rocks (Figs. 1 to 4) from the Raised Beach at Étel, Brittany; prepared and described by Mr. R. F. Gwinnell, B.Sc. The photomicrographs were prepared by Dr. H. H. Arnold-Bemrose, M.A., F.G.S., under crossed nicols.

Fig. 1. Section of a very fine-grained rock with a foliated structure. × 20 diam.
,, 2. Section of a specimen much coarser in texture, the quartz-grains very irregular in shape and size. × 20 diam.
,, 3. This section shows distinct foliation and the groundwork of smaller grains with two elongated crystals of greater dimensions. × 20 diam.
,, 4. In this the rock-structure is coarser than in any of the others, all the grains large and most of them elongated, foliation is well seen. × 20 diam.
,, 5. A holocrystalline rock, hypidiomorphic without porphyritic constituents, texture of medium coarseness. (French 'granulite'.) × 20 diam.

II.—On Two Deep Well-Sinkings at Leckhampton Hill, Cheltenham.

By L. Richardson, F.R.S.E., F.G.S.

Those who are acquainted with the detailed zoning of the Upper Lias and Inferior Oolite of the Cotteswold Hills have long desired to know the precise date of the Upper-Lias deposit at Leckhampton Hill, Cheltenham, upon which the Inferior Oolite rests. At last the desired-for information is to hand. The Inferior Oolite at Leckhampton Hill rests directly upon the *Variabilis*-Beds of the Upper Lias.

It has, of course, long been known that there is no Cephalopod-Bed, like that so well known in the neighbourhood of Dursley, at Leckhampton Hill. All the evidence available tends to show that the *Scissum*-Beds rest directly upon the *Variabilis*-Beds. That would mean that the *Opaliniforme-*, *Aalensis-*, *Moorei-*, *Dumortieria-*, *Dispansum-*, *Struckmanni-*, *Pedicum-*, and *Striatulum*-Beds were absent from Leckhampton Hill, and that there is a considerable non-sequence there between the Inferior Oolite and Upper Lias. As regards the Cotteswold Sands alone, "there is a loss of about 140 feet from Coaley Wood to Leckhampton Hill" (S. S. Buckman, *in litt.*, November 11, 1909).

Unfortunately, the actual junction of the Oolite and Lias could not be investigated in the deep well from which the fossils indicative of a deposit of *variabilis* hemera were obtained. The well had already long been made when the Birmingham Corporation acquired the Salterley-Grange Estate for the purpose of establishing a Sanatorium there for consumptives, and it had only to be cleaned out and deepened.

At all events, as far as can be gathered from evidence collected in the immediate neighbourhood, and what could be seen at the well-sinking itself, in the form of rock dug out, etc., the Inferior Oolite rests directly upon the greyish-blue sandy micaceous clays of *variabilis* date.

The well under consideration is situated between the two Hartley Cottages, which lie between Hartley Farm and the Sanatorium (see Map, Text-fig. 1). The site is now marked by the building that houses the pumping-engine.

Well at Hartley Cottages.—The well was commenced either in the *Clypeus*-Grit or Upper *Trigonia*-Grit. It is doubtful in precisely which, for about 60 yards along a trench that was dug for laying the pipes to connect another well (that in Hartley Bottom)

Fig. 1. Map (1 inch = a mile) to show the positions of the wells and trenches. (1) Hartley-Bottom Well; (2) Hartley-Cottages Well.

with this one, there appeared to be indications of a small fault, which brought the Upper *Trigonia*-Grit on the Hartley-Cottages well side into juxtaposition with the *Clypeus*-Grit.

From surface-level down to the top of the Upper Lias was 212 ft. 4 in. This thickness certainly includes a considerable portion of the Upper *Trigonia*-Grit. As the measurement made by me (*vide* Proc. Cotteswold Nat. F.C., vol. xv., pt. 3, 1906, p. 184) in the large quarries on the escarpment gave about 200 feet as the thickness of the Inferior-Oolite deposit *between* the Upper *Trigonia*-Grit and the Upper Lias, the one total confirms the other.

The details obtained at the Hartley-Cottages well may thus be summarized:—

Well-Sinking at Hartley Cottages, Leckhampton Hill.

		Thickness in ft.	in.
Inferior Oolite.	*Clypeus*- and Upper *Trigonia*-Grits.		
	Beds between the Upper *Trigonia*-Grit and Upper Lias	200	0
Upper Lias. (*variabilis.*)	1. Hard, greyish-blue sandy micaceous clay	3	9
	2. Yellow ferruginous, micaceous, indurated, sandy clay; *Nautilus*, *Belemnites* (phragmacones), small *Gryphææ* .	1	0
	3. Greyish-blue clay similar to 1	6	4
	4. More arenaceous but otherwise similar clay	1	0
	5. Greyish-blue sandy rock: *Belemnites* (near to *B. tubularis*, Y. & B.),[1] *Haugia grandis*, S. S. Buckman,[1] *Haugia* sp. indet.,[1] *Dactylioceras* cf. *Holandrei* (d'Orbigny),[1] *D.* cf. *mucronatum* (d'Orb.),[1] *Thysanoceras* sp. (fragment: ? *T. sublineatum*, Oppel, sp.),[1] *Syncyclonema demissus*, (Phillips), auctt.,[1] *Pleuromya* sp.[1]	1	8
	Bottom of well (226 *ft.* 1 *in.*). *Water ran away.*		
	Boring.		
	6. Sandy clay	11	9
	7. "Very fine blue sand": penetrated	23	3

[In this well the water-level stood at 210 ft. 1 in., and did not rise on the well being deepened, but ran away at 226 ft. 1 in.]

I am indebted to Mr. S. S. Buckman for naming the ammonites.

In connexion with the same water-supply scheme that required the deepening of this Hartley-Cottages Well, a new well was sunk near the cottages at the northern entrance to the wood in Hartley Bottom; and two trenches were dug—the one connecting the Hartley-Bottom well with that at Hartley Cottages; and the other, the well at the latter place with the Sanatorium.

The sites of the wells and the courses of the trenches will be apparent from the small map (Fig. 1).

Well in Hartley Bottom.—This well was commenced in the Oolite Marl and left off in the Pea-Grit. Some of the pieces of Pea-Grit that were dug out were as blue as Forest Marble.

Pipe-trench connecting the Hartley-Bottom and Hartley-Cottages Wells.—As already remarked, there appears to be a very slight fault at some 60 yards along the trench away from Hartley Cottages in the direction of the Hartley-Bottom well. Thence onwards, however, to within 150 yards of the latter well the trench was in the *Clypeus*-Grit, which was full of the ordinary fossils.

Above the *Clypeus*-Grit exposed in the trench—especially about the middle portion—was a foot or more of tough, purplish clay—residual soil from the weathering of the Fullers' Earth. In the stretch from 150 yards of the well to the well itself, was observed evidence of the Upper *Trigonia*-Grit (? Gryphite-Grit), *Buckmani*-Grit, Lower *Trigonia*-Grit, and Upper Freestone.

Pipe-trench between the Hartley-Cottages Well and the Sanatorium.—For the first 300 yards this trench was in the Upper

[1] These specimens are now in the Cheltenham Town Museum.

Trigonia-Grit, but then, as the surface of the ground declined in the field just to the north of the Sanatorium-bungalows, the oyster-layer on top of the Upper *Trigonia*-Grit, the thin representative of the Notgrove Freestone (with bored and oyster-covered top-layer), and Gryphite-Grit were successively proved. Then came a small fault, the Fullers' Earth being let down against the 'Grit'. The Fullers' Earth, is, however, only a small mass, for the *Clypeus*-Grit rises up from beneath it but a few yards farther on, and is excellently exposed in the vertically-cut bank at the back of the bungalows.

I am indebted to Mr. J. W. Gray, F.G.S., of Cheltenham, for much of the information upon which this paper is based. He obtained the details of the Upper-Lias deposits exposed in the well, and collected the fossils that afforded the information as to their date.

III.—Notes on a pre-Tertiary Dyke on the Usway Burn.

By Miss M. K. Heslop, M.Sc.

(PLATE XI.)

A DYKE of pre-Tertiary age is exposed in the lower course of the Usway Burn, a tributary of the Coquet. It is intruded among the Cheviot igneous rocks, and crosses the burn in a somewhat north-easterly direction. In hand-specimens the rock appears black or dark brown with a sub-vitreous lustre, and contains porphyritic crystals which are quite visible to the unaided eye. It weathers a bright red colour and even the fresh portions are streaked with red veins of agate.

In his paper on the Cheviot Andesites and Porphyrites,[1] Dr. Teall mentions a rock allied to pitchstone-porphyrite, which is exposed on the Coquet about a quarter of a mile above Windy Haugh. The description he gives of it would serve very well for the Usway Burn Dyke, but he deals chiefly with the nature of the prevailing pyroxene, and not at all with the minute structure of the rock.

Under the microscope the porphyritic nature of the Usway Burn Dyke is at once evident, large phenocrysts of felspar and pyroxene being embedded in a rather dark glass crowded with elementary crystals. Between these two extremes is a medium-sized set of crystals, which may be referred to as the ground-mass generation. There are some rounded masses of a black oxide of iron which bear such evident traces of corrosion that they must be classed, with the porphyritic elements, among the products of an earlier period of crystallization. It is extremely difficult to determine the order in which the crystals were formed—particularly as the limits of the generations are very ill-defined—but there can be little doubt that the apatite needles and small grains of iron oxide, which are both included in the porphyritic crystals, are the oldest secretions of the magma. The porphyritic pyroxenes are older than the felspars by which they are frequently enclosed. So that in this, the first generation, the

[1] "Notes on the Cheviot Andesites and Porphyrites," by J. J. Harris Teall, M.A., F.G.S.: Geol. Mag., April, 1883.

minerals crystallized out in the following order: (1) and (2) apatite and iron oxide, (3) pyroxene, (4) felspar. The same order is preserved in the ground-mass generation, with the addition of a micaceous oxide of iron towards the close of the period. It is remarkable, however, that felspar laths of the normal ground-mass type are included in the porphyritic pyroxenes, and sometimes in the outer zones of the large felspars. At present there is no really satisfactory way of accounting for this apparent contradiction to the observed order of formation. In the last generation the elementary felspars take precedence of the pyroxenes, while much of the iron oxide still exists in an unindividualized state. There is apparently some overlapping of the periods of formation, but the crystals are classed chiefly by their state of preservation and their size.

The following figures give some idea of their relative dimensions. The first number in each bracket refers to the length, and the second to the breadth of the section.

Porphyritic felspars (1·14 × ·61 mm.), (1·96 × ·46 mm.), (1·32 × ·70 mm.) are of common occurrence, while (·43 × ·28 mm.) is very small.

Porphyritic pyroxenes, longitudinal sections: (1·4 × ·53 mm.) is large; (1·12 × ·18 mm.) and (·96 × ·50 mm.) are more usual; (·36 × ·24 mm.) is small. Some cross-sections are (·76 × ·71 mm.), (·39 × ·32 mm.), (·52 × ·50 mm.). Longitudinal sections of the ground-mass felspars vary from (·34 × ·18 mm.), which is unusually large, to (·035 × ·011 mm.); the average size is about (·12 × ·03 mm.). The largest cross-sections do not exceed (·12 × ·21 mm.), and are generally very much smaller. Longitudinal sections of ground-mass pyroxenes vary from about (·150 × ·180 mm.) to (·051 × ·027 mm.). When smaller than this they are commonly included among the elementary forms.

The *porphyritic felspars* may, for the convenience of description, be divided into three groups.

1. In the first are those with sharp angles, and clear, well-defined edges (see upper phenocryst in Figs. 1 and 2, Pl. XI). They are characterized by a combination of simple twinning with that of the albite type, e.g. one-half of a crystal may be untwinned while the other shows the ordinary albite striæ. Glass inclusions are common, but not conspicuous, and although traces of zoning have been observed, they are most indefinite, and entirely confined to the outer limits of the crystal.

2. A second set comprises those felspars which have a deep peripheral zone of glass inclusions, bounded by a complete though narrow zone of felspar material. These crystals are characterized by rounded angles and clear twinning of the albite type. They are usually made up of several particles, intergrown under plutonic conditions, apparently in some cases, then, *as a group*, furnished with a zone of glass inclusions and an outer felspar envelope, while at other times it is clear that these were added *before* the particles were grouped together, for each possesses complete zones of its own.

Sections of these groups *in* the zone of inclusions are apparently riddled with glass (see lower phenocryst in Figs. 1 and 2, Pl. XI), and consist more of glass than of felspar, but the condition of the section does not necessarily indicate that of the whole crystal or crystalline group.[1]

3. The third set is characterized by deep zoning, sharp edges, few inclusions, and very indefinite twinning. Although distinct, these three types are probably due merely to different directions of the sections, or at most to slightly different physical conditions during growth. They do not imply three generations of porphyritic felspars.

The *ground-mass felspars* are broader and shorter than those which commonly occur in the post-Tertiary dykes of Northumberland and Durham.[2] They show a combination of binary and multiple twinning, and on the whole are very free from inclusions, although they do sometimes contain rounded or oval patches of dark glass, and are pierced by apatite needles. They are very markedly zoned.

The *porphyritic pyroxenes* are exactly like those which are described by Dr. Teall in the paper to which I have already referred. There he concludes that the prevailing pyroxene in the Cheviot Andesites and Porphyrites is not, as was previously supposed, *augite*, but *hypersthene*.

In the pyroxene of the Usway Burn Dyke, sections which are cut perpendicular to the prism are octagonal, but the pinacoidal faces are largely developed at the expense of those of the prism (see Figs. 5 and 6, Pl. XI). Cleavages parallel to both are usual, but that of the prism is the more distinct. These sections are decidedly pleochroic, the colour changing from yellow to reddish brown. They show straight extinction, and, in the vast majority of cases, a bisectrix in convergent light. Longitudinal sections, in which pleochroism changes the colour, from *green* for rays vibrating parallel to the length of the section, to *yellow*, for those vibrating at right angles to it, also show the point of emergence of a bisectrix, usually giving a much clearer figure than the cross-sections. They also show straight extinction. The cases in which an optic eye is obtained are various, but they generally have good traces of the brachypinacoids, and sometimes of the dome faces.

A combination of these sections gives a crystalline form like that described by Dr. Teall as a "columnar doubly-terminated crystal, which is made up mainly of the pinacoidal and only to a slight extent of the prismatic faces", while the consideration of the pleochroism and the interference figures shows that we are dealing with a crystal in which the axes of elasticity coincide with the crystallographic axes, so we are justified in assuming that it is orthorhombic. That it is hypersthene and not enstatite or bronzite is shown by the strong pleochroism, and the constant occurrence of the clearest interference figure (bisectrix) in the least pleochroic sections (green and yellow), and the occurrence of a less definite figure in the normal

[1] Teall, Geol. Mag., 1887, "Notes on Cheviot Andesites and Porphyrites," p. 150: "In this case the bulk of the foreign matter must be greater than that of the felspar substance, and yet the felspar has impressed its character on the compound mass."

[2] Teall, Q.J.G.S., 1884, p. 229.

transverse sections—in other words, the acute bisectrix coincides with the brachydiagonal and the crystals are negative. These are the characteristics of hypersthene.

Dr. Teall claims that a monoclinic pyroxene is also present in the Cheviot igneous rocks, and mentions twinning (parallel with the pinacoids) which, he suggests, only takes place in the monoclinic mineral. Twinning parallel both to the prism and pinacoids may be seen in the Usway Burn pyroxene, but it is found sometimes in crystals which are undoubtedly orthorhombic. There are, however, certain sections noticeable in ordinary light for their irregular outlines, deep cleavage, and dark colour—but little changed by pleochroism—and between crossed nicols for their brilliant interference colours and frequent twinning. There can be little doubt that they are monoclinic crystals of augite. Sections perpendicular to the prism give, in convergent light, a dark arm surrounded by coloured bands. Sections parallel to the prism give various and somewhat doubtful figures, never a good bisectrix.

In a much decomposed specimen of the rock, all the large well-formed pyroxenes are altered to colourless masses streaked with green fibres of chlorite, and including little dark rods. Patches of the original mineral may sometimes be found towards the centres of these crystals, and in one or two cases the fresh portion was distinctly twinned. It would be difficult to say, in these circumstances, whether the fresh portion is orthorhombic or monoclinic, but that the whole crystal was originally orthorhombic is beyond question. In this altered specimen the only wholly fresh crystals are those described above as augite, and although some orthorhombic sections are only partially decomposed, they belong to the ground-mass generation. It would seem, then, that both orthorhombic and monoclinic pyroxenes are present, but that the former is either *older* or *more readily decomposed* than the latter; also that twinning is common to both, and is probably, in the orthorhombic mineral, a precursor of decomposition, perhaps of optical re-orientation.

It is difficult to draw a definite line between the porphyritic and ground-mass pyroxenes. The latter, unlike the felspars of their own generation, occur in exactly the same way as their porphyritic equivalents. They are always surrounded by a little halo of pale yellow material with which the incomplete crystals (of common occurrence) are intergrown in a way that recalls the micro-pegmatitic intergrowth of quartz and felspar (see photographs 5 and 6). There is no clue, however, to the identity of the intergrown substance in the case we are considering, for although it is not absolutely isotropic, its interference effects are too feeble to be of any use. These incomplete crystals may be correlated with the incomplete prisms of the third generation, a description and suggested explanation of which is given later.

In a decomposed specimen of rock, the pale zones surrounding altered pyroxenes, both large and small, become very conspicuous, and contain tiny prisms of the fresh mineral, lying with their axes parallel to those of the large crystals to which they are attached.

The Glassy Base.

With low powers it looks as though the porphyritic and ground-mass crystals were embedded in an almost homogeneous dark-brown background; but when the latter is examined with higher powers, it appears that the ultimate base is colourless and contains numbers of brown patches which give the characteristic colour. These patches have borders of a yet darker hue (see Fig. 4, Pl. XI), and from their corners send out processes into the clear base. The highest powers cannot resolve the brown areas into any constituent part, but it may readily be seen that the dark edges are due to numbers of globulites which also form the processes, being carried out apparently on a central thread of material from the patch.

The dark areas show a marked tendency towards angularity of shape, many are rectangular, while others have more hexagonal outlines. They are considerably deformed by the protrusion of the globulitic processes, which, besides obliterating the corners, curve the sides. Some are quite shapeless. The colour of the glass is greatly intensified by numbers of small reddish-brown hexagons of a micaceous oxide of iron, probably hæmatite (see Fig. 4 in Plate). These little plates are never very thick, for sections perpendicular to them always give quite narrow dark needles. Irregular grains of a black oxide of iron are fairly common. They have never been known to show any definite crystalline form, and are probably in a very elementary stage of development. Crystals of the iron oxides, like those of the pyroxene (see Fig. 5, Pl. XI), are surrounded by light-coloured areas when embedded in a dark patch. Apatite is repeated in this generation in small but very perfect needles, which pierce all the other crystals and are certainly older than most of them, although the precise relation of their age to that of the apatites of earlier periods of crystallization is somewhat obscure. The early felspars are of the same type as those of the ground-mass. The crystals in this case, however, are only solid at the centre, and grow in hollow tubes in both directions, consequently longitudinal sections show the well-known 'hour-glass' structure (see Fig. 3, Pl. XI), while cross-sections of any but the central part show square colourless frames of felspar material filled with glass. No globulitic stage of felspar growth has yet been seen, the very earliest recognizable forms being faint colourless streaks, only visible when surrounded by dark glass.

The simplest elementary pyroxenes are short cigar-shaped prisms which occur either in pairs or groups, rarely alone. All possible combinations of these have been observed. The pairs are attached at their centres, while the ends of both curve away from each other, thus imitating the 'hour-glass' structure of the felspars. Some assume the usual skeleton form, consisting of a central stem with little perpendicular arms attached on either side; others adopt the curving acanthus-like structure which is so strongly developed in the Collywell and Crookdene Dykes of Northumberland.[1]

[1] "Notes on the Crookdene and Related Dykes," by M. K. Heslop, M.Sc., and Dr. J. A. Smythe, read before the Geological Society, November 17, 1909.

The largest elementary pyroxenes are prismatic in shape, and they appear to grow by the addition of material at the corners, and it is remarkable that quite detached particles are often arranged *in line* with each other and with the edge of a small pyroxene, for considerable distances. In one case a 'process', about ·0375 mm. in length, protrudes from the end of a small prism of pyroxene, and is made up of several apparently quite detached particles. The intervals between them are too minute to be correctly estimated—it is quite evident, however, that each piece is separate.

This kind of growth seems to prevail among the elementary pyroxenes, because, not only are there innumerable examples of it, but in the more advanced crystals cross-sections with good octagonal forms and sharp angles often show a gap filled with glass running across the centre of the section almost at right angles to the pinacoids (see Figs. 5 and 6, Pl. XI). If we refer again to the simplest elementary pyroxenes, those consisting of two cigar-shaped needles joined at the centre, but with tapering ends diverging apart, we see that there is a tendency for pyroxene to grow in incomplete, perhaps hollow, prisms from a solid centre, as in the case of the 'hour-glass' felspars. This, no doubt gives rise to the centrally incomplete sections which have just been described, and to the intergrowth of pyroxene with the pale yellow material—again in incomplete crystals—which occurs in the ground-mass generation (see description of ground-mass pyroxenes). The gaps are always filled by this pale yellow, feebly doubly-refracting substance, which seems indeed to have been brought almost to a crystallizable state by the subtraction of pyroxene material to build the crystals of that mineral.

In one slide the glass is in a much more developed stage. The base is still colourless, but there is a marked increase in the number of elementary crystals, especially the iron oxides and the little pyroxene needles. The brown patches have practically disappeared, but their final stages may be recognized in the small clouds of dark granules which are usually associated with elementary pyroxenes.

A practically unbroken transition from the dark granules to definitely hexagonal plates of micaceous iron oxide has been made out. With a magnification of 1000 diameters, very small granules may be seen to possess hexagonal outlines, and although many may belong to the black oxide, there can be little doubt that the brown patches of the normal glass are here very largely represented by hexagons of micaceous oxide of iron.

In the same way, and with equal certainty, a transition from the globulitic processes of the brown patches to the elementary cigar-shaped pyroxenes may be traced. These may be certainly identified by their interference colours, needles with a thickness of less than ·00236 mm., giving quite recognizable interference tints. It is impossible to say definitely whether these early forms are orthorhombic or monoclinic, but the number of cases in which the extinction is *oblique* suggests the latter.

The association of pyroxene and iron oxide in the brown patches is similar to the association of the basic elements, augite and iron oxide, in the 'basic globulite' of the post-Tertiary Dykes of Northumberland.

A careful study of the mode of occurrence of elementary crystals in them shows that the growth of a skeleton augite is almost invariably accompanied by the elimination of iron oxide at intervals along the stem and arms of the skeleton crystal. *Here*, the reverse occurs. The brown patch (which may be regarded as an enlarged basic globulite) contains the ingredients both of the pyroxene and iron oxides, the latter apparently in excess of the former. The pyroxenic constituent separates out in globulitic forms, segregates at the edges of the patches, and is gradually eliminated as the globulitic processes break off and become definite elementary pyroxenes. It is not suggested that after this the brown patch merely assumes hexagonal outlines—although its somewhat marked angularity seems to indicate an inclination to do so. The process is, no doubt, much less simple, and must involve a differentiation between the hæmatite and the black oxide of iron; but it is certain that these minerals do assume a more or less definite crystalline form after concentrating as much as possible, and so eliminating the pyroxenic material.

EXPLANATION OF PLATE XI.

Rock-sections, pre-Tertiary Dyke, Usway Burn.

Fig. 1. This shows the general structure of the rock. There are two types of porphyritic felspars: the upper one belongs to the first set, and has few inclusions and clear sharp angles and edges. The lower one has rounded angles and is riddled with inclusions: it belongs to the second set. × 22·6 diameters.

,, 2. Shows the same field between crossed nicols.

,, 3. This shows the mode of occurrence of the elementary felspars. The 'hour-glass' structure is well seen in the small longitudinal section which occurs near the centre of the field. × 260 diameters (approx.).

,, 4. This emphasizes the dark borders of the brown patches, and shows the globulitic nature of the processes. In the centre of the field there is a small hexagon of the micaceous iron oxide, in which different thicknesses (due to incomplete cleavage-plates) have produced different intensities of colour. × 260 diameters (approx.).

,, 5. An incomplete pyroxene is seen here. Although it occurs in a dark patch, it is surrounded by a zone of light-coloured material, which also fills the gap extending across the centre of the crystal. There are several small detached pieces of pyroxene near the lower left-hand corner of the crystal. × 208·3 diameters (approx.).

,, 6. Shows the same with nicols crossed. This brings out clearly the isotropic nature of the colourless material which forms the zone and the central inclusion.

IV.—Note on a Mounted Skeleton of a Small Pliosaur, *Peloneustes philarchus*, Seeley, sp.

By C. W. Andrews, D.Sc., F.R.S., British Museum (Natural History).[1]

(PLATE XII.)

THE skeleton figured on Plate XII is that of a small Pliosaur, *Peloneustes philarchus*, Seeley, sp. This specimen was obtained from the Oxford Clay in the neighbourhood of Peterborough by Mr. A. N. Leeds, F.G.S., to whom the British Museum is indebted for a great series of more or less perfect skeletons of many species of

[1] Published by permission of the Trustees of the British Museum.

1

× 22·6

2

× 22·6

3

× 260

4

× 260

5

× 208·3

6

× 208·3

Rock-sections from pre-Tertiary Dyke, Usway Burn.

Oxford Clay Reptiles, including the beautifully preserved and nearly complete examples of *Cryptocleidus oxoniensis* and the remains of *Cetiosaurus leedsi*, now mounted in the Gallery of Fossil Reptiles. So far as I am aware, this is the first skeleton of a Pliosaur that has been mounted so as to show the true form of the body in those reptiles. All the bones belong to a single individual, but the left-hand paddle and the distal portion of the other paddles being wanting, they have been represented by plaster models made from the paddles of another individual, which are exhibited on the floor of the case. The left ischium has been modelled from that of the opposite side.

Peloneustes philarchus was first noticed by the late Professor H. G. Seeley[1] under the name *Plesiosaurus philarchus*. Subsequently Mr. Lydekker[2] gave a more complete account of the species and referred it to a new genus, *Peloneustes*. The structure of the skull was described by the present writer in the Ann. Mag. Nat. Hist., 1895, ser. VI, vol. xvi, p. 242.

Peloneustes, though considerably smaller than the other Pliosaurs, exhibits all the characters peculiar to that family, viz. relatively large head, short neck with double-headed cervical ribs, absence of a median symphysis of the scapulæ, greatly elongated ischia, and hind paddles larger than the fore. Mr. Lydekker, however, considers that in some respects it is more primitive than the larger forms, and tends to bridge the gap between them and the true Plesiosaurs.

The skull, which in the present specimen is somewhat crushed and distorted, is relatively large and the snout is considerably elongated, the length of head being about two and a half times its width at the posterior end. There are six teeth in the premaxilla, and twenty-eight to thirty in the maxilla; in the lower jaw there are about thirty-five teeth on each side, of which fifteen to sixteen are in the symphyseal region. The teeth themselves are slender and sharp-pointed; they are circular in section, and the enamel-covered crown bears numerous fine longitudinal ridges, some of which extend to the apex. The neck is short, and is composed of twenty-one or twenty-two vertebræ, including the atlas and axis; the centra are short and slightly biconcave, the neural arches and spines are high. All the cervicals behind the united atlas and axis, with the exception of the last, bear double-headed ribs, but the facets for the upper and lower heads are separated by a slight ridge only; the last cervical seems to have had only one head, and the same is the case with the pectorals and dorsals. Of these there seem to have been two or three of the former and twenty-two or twenty-three of the latter, all bearing comparatively slender ribs. The number of sacral and caudal vertebræ is not definitely known.

The shoulder-girdle is typically Pliosaurian, the coracoids are large thin sheets of bone; the scapulæ are triradiate, but the ventral rami do not meet one another in the mid-ventral line, nor do they meet the coracoid. Some specimens show that a triangular interclavicle was interposed between the ventral ends of the scapulæ. The fore paddle

[1] *Index to Aves, etc., in the Cambridge Museum*, 1869, p. 139.
[2] Quart. Journ. Geol. Soc., 1889, vol. xlv, p. 48.

is smaller than the hind; the humerus is only slightly expanded at its lower end, and the rest of the paddle is long and slender. The pelvis consists of small rod-like, backwardly sloping ilia, great thin plate-like pubes, and the greatly elongated ischia characteristic of the family. As usual in the group, the ilium is not in contact with the pubes in the acetabulum. The greatly expanded coracoids, pubes, and ischia formed an almost continuous bony floor to the body, and the short interval between the posterior edge of the coracoids and the anterior edge of the pubes was filled by a plastron of ventral ribs; in the mounted specimen this is represented only by three of the median ventral ribs, which are fused with one another on the middle line.

The hind paddles, though larger, are closely similar in form to the fore paddles. The total length of the specimen as mounted is 11 ft. 6 in. The dimensions in centimetres of some parts of this skeleton are—

Skull, length	55·7	centimetres.
Mandible, length	67·0	,,
,, length of symphysis	21·4	,,
Coracoid, greatest length	47·0	,,
Humerus, length	33·0	,,
Pubes, length	33·8	,,
Ischium, length of median expansion	37·0	,,
Femur, length	39·0	,,

V.—Glacier Granule-markings.

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

(Plate XIII.)

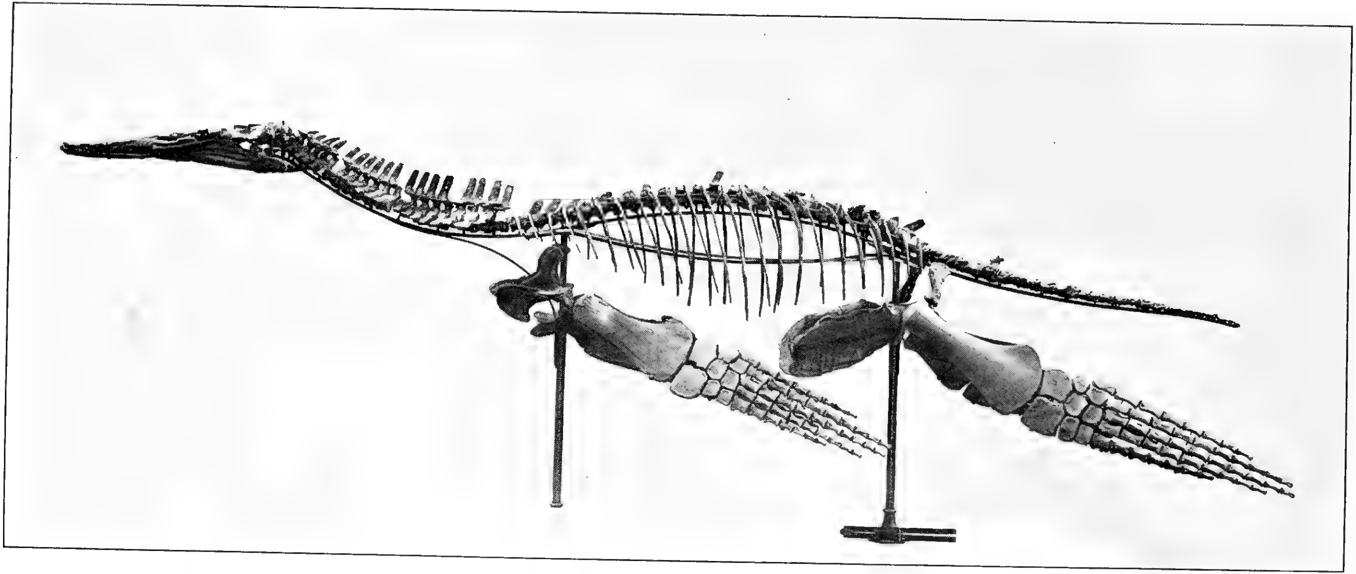
I HAVE already described the granular appearance of glacier ice as seen in polarized light[1] and also the striations on the granules as shown by pencil rubbings.[2] Last summer I succeeded in obtaining exact reproductions, in plaster of Paris, of the ice surface-structure in the upper cave in the Rhone Glacier. These are shown in Figs. 1–3.

The casts were obtained in the following manner. Plasticene, a substance used for modelling, having been cooled to the temperature of the ice, was pressed against the wall of the cave. When all the conditions were favourable the surface of the plasticene took an exact impression of the ice-surface. A cardboard ring, obtained from a pillbox, the top and bottom of which had been removed, was then pressed upon the surface of the plasticene and filled with liquid plaster of Paris. When the plaster had properly set the plasticene and cardboard were removed. Photographs of these casts, as will be seen from the photos reproduced, give very good representations of the ice markings (see Plate XIII).

A careful examination of well-marked granules in which liquid cavities had been produced by a burning-glass showed that the ridges and furrows in each grain were along planes at right angles to the optic axes of the granules. It is clear, therefore, that the direction of the markings is determined by the crystalline structure of the ice.

Fig. 2 is a print of a portion of the surface of a large glacier granule, and Fig. 1 shows portions of several granules. Fig. 3 is

[1] Geol. Mag., 1895, p. 152. [2] Ibid., 1907, p. 529.



Skeleton of *Peloneustes philarchus*, Seeley, sp. Oxford Clay, Peterborough. About $\frac{1}{20}$ natural size.

a still further enlargement of a portion of Fig. 2 to show more clearly the details of the surface-structure. It will be seen that both the ridges and the furrows frequently bifurcate, and that whilst maintaining their general direction across the granules they curve about considerably. Fig. 1 shows several granules abutting against each other. The most marked feature is that some of the surfaces of the granules occupy depressions, whilst others project above the general level of the surface. The surface was originally quite level, and evaporation and melting have taken place on the surfaces of some of the granules more rapidly than upon others. The coarseness of the grooving on different granules varies somewhat. In Fig. 1 all the granules differ in this respect. Compare the fineness of the grooving on the larger granule with the coarse incipient grooving on the top one.

The rubbings I had previously obtained seemed to show that even when protected from the sun, as in a cave, each granule was separated from its neighbour by a canal of more or less width. These actual impressions, however, make it clear that this appearance was produced by the pencil passing from raised to depressed granule surfaces and vice versa. Sometimes the grooving of the surface of the lower crystal is not well marked near its junction with other granules. This is probably the result of capillary forces causing water to collect along the line of junction. Evaporation rather than melting appears to be the main cause of the appearance of the surface-structure we are considering. It occurs at all points in caves both in the light and in the dark. Ventilation appears to have the most marked effect on its appearance; for the surface-markings were very well developed in many of the crevasses intersecting the ice cave.

I have never seen the structure on lake ice, pieces of which have been exposed in a freezing atmosphere. Shear planes in the granules, produced by the differential motion of the glacier might produce the ridges and furrows. O. Mugg[1] says "broken surfaces, *especially those of bent bars of ice*, almost always show a fine striation". With regard to McConnell's work on the bending of ice Mugg[2] says, "As McConnell died during these experiments I decided to take them up again, and especially to make the experiment to produce in the ice the pure translation without curvature and also if possible to ascertain the direction of the translation." "The result was a complete confirmation of McConnell's experiments." Mugg's investigation was a very exhaustive one from the point of view of the chemist and crystallographer.

The microscopical examination of polished surfaces of alloys which have been sheared shows that the distortion takes place along definite shear planes in the crystals and not equally throughout the mass, as in amorphous liquids. Crystalline ice, it would appear, also shears along definite planes, and the distortion in the crystalline structure along such planes results in differences of surface evaporation, which give rise to the surface ridges and furrows.

[1] *Jahrb. für Min.*, 1895, p. 217.

[2] Ibid., pp. 213, 214.

From these considerations it appears that the differential motion of glaciers is partly the result of viscous shear between adjacent granules; partly of viscous shear along planes at right angles to the optic axes of the crystalline granules; partly of the plastic shearing into separate pieces of the granules and to the viscosity imparted to the general mass by the growth of one crystal at the expense of another. It is to this latter giving way of the points of attachment between granule and granule, owing to molecular movements at their interfaces, that the general viscosity of the glacier depends. The deformation of the granules by stress and the formation of extensive shear planes by the breaking up of granules are secondary effects.

EXPLANATION OF PLATE XIII.

Fig. 1 shows a portion of the ice surface, consisting of several granules, in the Upper Cave of the Rhone Glacier, magnified 2·5 diam.

Fig. 2 shows the surface of a large granule in the same cave, magnified 2·5 diam.

Fig. 3 shows an enlargement of a portion of the surface of the granule in Fig. 2, enlarged to 10·8 diam.

VI.—Some Fossil Annelid Burrows.[1]

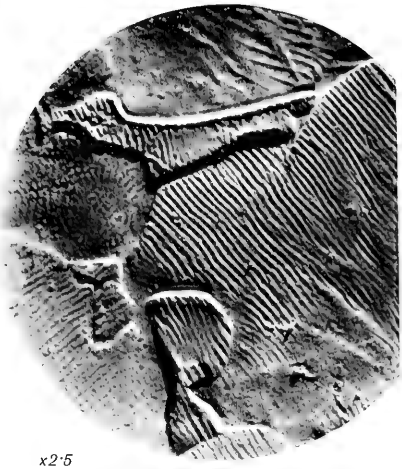
By Dr. F. A. Bather, M.A., F.R.S.

In the little note on "Fossil Representatives of the Lithodomous Worm *Polydora*" which appeared in the Geological Magazine for March, 1909 (pp. 108–10), it is said that, "so far as I can ascertain, this genus has not hitherto been recorded in a fossil state." It has since come to my knowledge that I was not the first so to record it, and I therefore ask permission to make the necessary emendation.

In March, 1908 (Bull. Soc. géol. France, ser. 4, vol. vii, pp. 361–70, pl. xii), Professor Henri Douvillé published a paper on "Perforations d'Annélides", in which he figured a surface of Jurassic rock, from near the fort of Arrabida in Portugal, penetrated by burrows characteristic of *Polydora*. Since these Jurassic rocks are covered by others of Helvetian age, the borings cannot be of later date than Middle Miocene. These perforations, which were first observed by Mr. P. Choffat (December, 1906, Bull. Soc. géol. France, ser. 4, vol. vi, p. 237), are about twice as large as those of *Polydora ciliata*, and are therefore compared by Professor Douvillé with those of *P. hoplura* Claparède. He adds: "On pourrait réserver à ces perforations la terminaison *ites* et les désigner sous le nom de *Polydorites*." Since no distinction can be drawn between the borings thus named *Polydorites* and those made by *Polydora*, it appears that 'Polydorites' is not intended as an independent generic name, but merely as a brief way of writing 'fossil traces of *Polydora*'.

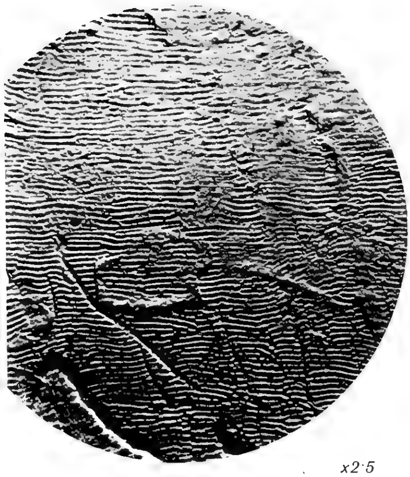
Polydora hoplura is a British species, though not so common as *P. ciliata*. Others placed in the British list by Professor W. C. M'Intosh (February, 1909, Ann. Mag. Nat. Hist., ser. 8, vol. iii,

[1] Published by permission of the Trustees of the British Museum.



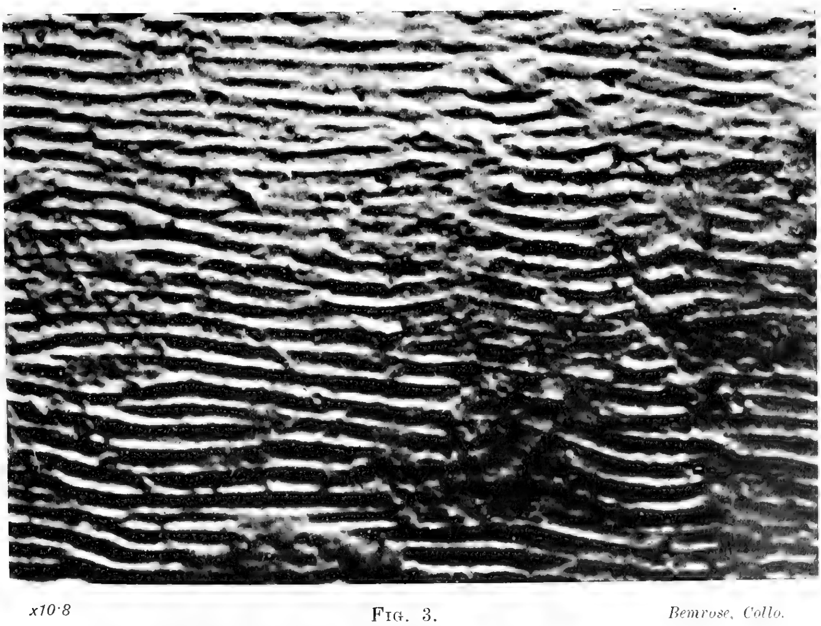
x2·5

Fig. 1.



x2·5

Fig. 2.



x10·8

Fig. 3.

Bemrose, Collo.

Striations on Glacier Granules.

pp. 169–74) are *P. caeca* Oersted, *P. flava* Claparède, *P.* cf. *quadrilobata* Jacobi, and *P. Carazzi* n.sp.

Professor Douvillé is inclined to refer to an annelid of the same Family (Spionidæ) some U-shaped galleries described by Professor Carlos I. Lissón (1904[1]) under the name *Tigillites Habichi* n.sp. These occur in stratified quartzites around Chorillos, south of Lima (Peru), and are assigned by Professor Lissón to a post-Neocomian but pre-Tertiary age, because the quartzites are covered (though not quite conformably) by nodular and vari-coloured quartzites containing ammonites which he refers to *Sonneratia.* Mr. G. C. Crick does not consider that the figures and descriptions warrant this reference, and he inclines to agree with Mr. W. M. Gabb, who regarded the ammonite described by himself from this horizon as of Kimmeridgian or Corallian age. However this may be, Professor Douvillé seems to have made a slip in calling these rocks "quartzites paléozoiques des environs de Callao."

While it seems probable that these tubes are not congeneric with the somewhat larger palæozoic *Tigillites,* there are objections to classing them with the smaller *Polydora.* The latter annelid makes littoral or inter-tidal borings into the hardened rocks of the shore. The tubes of *T. Habichi,* on the other hand, were formed in soft sand, *pari passu* with its deposition, a fact clearly indicated by their upward passage through successive laminæ, and the successive withdrawals of the curved bottom of the U to a higher level. The mere fact that weathering occasionally reduces the double opening of the tube to a single more or less keyhole-shaped opening, as in *Polydora,* is not enough to outweigh these differences.

That a keyhole-shaped opening is not in itself sufficient evidence of the work of *Polydora* follows from the studies of Dr. D. Carazzi on "La perforazione delle rocce calcaree per opera dei datteri (*Lithodomus dactylus*)" (1892, Atti Soc. Ligustica, iii, pp. 279–97), where it is shown that the aperture of the burrow, at first circular, soon assumes an elliptical outline, which eventually becomes constricted along the minor axis, until the shape is almost that of an **8**, with one half smaller than the other. The fragment of bored rock-surface, as figured by Dr. Carazzi on a reduced scale (p. 293), forcibly recalls the traces of *Polydora.* But the burrows have no septum to give them a U-shape, and their natural size (to judge from specimens in the British Museum) is about half-an-inch along the major axis.

Professor Douvillé, accepting the views expressed by Mr. Clifton J. Sarle in February, 1906,[2] proceeds to discuss some forms hitherto referred to *Taonurus.* Mr. Sarle came to the conclusion that *Arthrophycus* Hall, *Dædalus* Rouault (= *Vexillum* Rouault), *Taonurus* Fischer-Ooster (= *Spirophyton* Hall, *Alectorurus* Schimper, *Physophycus* Schimper, *Cancellophycus* Saporta, *Glossophycus* Saporta & Marion) were traces of burrows formed by sedentary Polychæta in rather

[1] "Los Tigillites del Salto del Fraile y algunas Sonneratia del Morro Solar: contribución á la geología de los alrededores de Lima," Bol. Cuerpo Ingen. de Minas Perú, No. 17, 64 pp. Lima, 1904.

[2] "Arthrophycus and Dædalus of Burrow Origin," pp. 203–10; and "Prel. Note on the Nature of Taonurus", pp. 211–4: Proc. Rochester Acad. Sci. iv.

loose sedimentary rock of various ages. He also referred to *Taonurus* some traces previously placed under *Taonichnites* (*Medusichnites*) Matthew and *Zoophycos* Massalongo. And with all these forms he compared *Dictyodora liebeana* Weiss, *Arenicolites duplex* Williams, and *Rhizocorallium* Zenker (= *Glossifungites* Lomnicki). As regards the last-mentioned genus, to which he referred forms included under *Taonurus* by Saporta and others, Mr. Sarle wrote that they "were produced by the packing of sediment along the radial side of a reclining U-shaped burrow of two openings, as it was repeatedly shifted and lengthened". The forms discussed by Professor Douvillé are *Taonurus ultimus* Saporta & Marion, Miocene, *T. Panescorsei* Saporta and Marion, Trias, *T. Saportai* Dewalque, Senonian. The last-mentioned, at all events, occurs on the worn surface of the Chalk, and the burrows are filled with silica and glauconite from the overlying Landenian. Professor Douvillé regards the burrows as hollowed by a Spionid of large size living in the Lower Eocene sea. On account of their form he separates them from *Taonurus*, and adopts the name *Glossifungites* Lomnicki (1886, Sprawozd.Kom. fizyjog. Akad.Umief.Krakowie, xx, p. (99), pl. iii, f. 64) of which the genotype is *G. saxicava* of Miocene age. If, however, this last is really the same as *Rhizocorallium* Zenker (1836, "Historisch—topogr. Taschenb. v. Jena", pp. 202–19), then that name must be preferred. The genetype is *R. jenense* Zenker (locc. citt.) occurring at the base of a thin bed of dolomite in the Bunter Marls near Jena.

A good account of the older literature bearing on these curious forms will be found in the well-known memoir by S. Squinabol, "Alghe e Pseudoalghe fossili italiene" (1890, Atti Soc. Ligustica, i, pp. 29–49, 166–99). Most of them have generally been referred to a supposed Family of Algæ, the Alectoruridæ. These have previously been discussed by Professor Th. Fuchs, who has recently accepted the views of Sarle and Douvillé (December, 1909, Mitt. Geol. Ges. Wien, ii, pp. 335–50) and has extended a similar explanation to such forms as *Vexillum Morieri* Sap., *V. Rouvillei* Sap. (= *Phycodes circinnatus* Richter), *V. Desglandi* Rouault, *Chondrites flabellaris* Sap., and *C. affinis* Sternb. In short, it seems probable that a large number of forms previously placed by geologists in a convenient receptacle labelled 'Fucoids' may now be safely regarded as due to burrowing annelids. I am not, however, prepared as yet to agree with Professor Douvillé that those annelids belonged to the family Spionidæ.

Mr. Linsdall Richardson, who discovered in the Rhætic conglomerate the bored pebble described in my previous note, seems subsequently to have found further examples, for he says in a report of an "Excursion to the Frome District, Somerset" (October, 1909, Proc. Geol. Assoc., xxi, on p. 223), that the conglomerate contains "pebbles of chert and Carboniferous Limestone that were well bored by the Lithodomous *Polydora ciliata* (Johnston)". I must repeat my opinion that "the worm . . . may well have been a *Polydora*, but it was not *P. ciliata*".

VII.—On the Horizon of the Lower Carboniferous Beds containing *Archæosigillaria Vanuxemi* (Göppert) at Meathop Fell.

By Professor E. J. Garwood, M.A., Sec. Geol. Soc.

In a note on *Archæosigillaria Vanuxemi* and *Bothrodendron* sp., published in the Geological Magazine for February last, Mr. J. W. Jackson speculated on the age of the beds at Meathop, in which these plant remains occur, and refers to the general classification of the Lower Carboniferous rocks of the Westmorland district, which I gave in this magazine in 1907.[1] He remarks: "It is perhaps premature to attempt to fix definitely the exact horizon of these beds, as they appear to have been as yet but superficially studied."[2] Since the classification above referred to was published, I have devoted such time as could be spared from professional duties to an exhaustive examination of the whole northern area, the result of which has been to confirm the general conclusions already given in this magazine. In my forthcoming account of the district, I have given a detailed description of the Meathop section. The delay in publishing a full account of the northern area has been necessitated by the general structure of the district, which required a careful study of isolated outcrops, extending over a very large area, before an accurate co-ordination of the separate exposures could be established. If any justification for this delay were needed, it is supplied by Mr. Jackson's note, in which he confesses his inability to decide upon the age of the beds displayed in the isolated exposure at Meathop on the evidence afforded by the collections obtained during his visits to that locality.

On my first visit to this section some years ago I obtained only a scanty fauna, giving inconclusive evidence of the horizon, and it has required very careful and close collecting during repeated visits before the beds could be definitely correlated with those occurring in other portions of the district where the horizons could be accurately determined. Pending the publication of my detailed description it may therefore be of interest to give here the conclusions arrived at regarding the age of the Meathop beds and the evidence upon which it is based.

My further work in the district since the provisional classification was published proved conclusively that the Meathop beds were correctly correlated with the lower dolomites of Shap and Brigsteer, and represent the lower portion of Dr. Vaughan's C horizon in the Bristol area. This is clearly shown by a comparison of the Meathop fauna with that of the beds in the Shap exposures. In my previous notes I laid emphasis on the importance of the Arnside *Michelinia* bed as furnishing a definite horizon in the northern sequence, and regretted the absence of beds containing this characteristic fauna from the Shap district. At the same time I gave evidence in support of the contention that the *Michelinia megastoma* bed must be represented in that district by the base of the Ashfell Sandstone, or by the top of the Shap dolomite. This contention has now been fully corroborated by the finding of *Michelinia* itself in the *Camarophoria isorhyncha*

[1] Geol. Mag., 1907, Dec. V, Vol. IV, pp. 70–4. [2] See table, op. cit., p. 73.

bed in the lowest layer of the Ashfell Sandstone of the Shap area; the further interesting discovery two years ago of *Michelinia megastoma* with *Camarophoria isorhyncha* on the summit of Meathop Fell no longer leaves any reasonable doubt as to the horizon to which these beds belong.

Mr. Jackson mentions the occurrence of *Spirifer* cf. *furcatus* (McCoy) and *Productus* aff. *corrugatus* (McCoy) in addition to the forms already given in my original account of the beds. This *Spirifer* bed forms a well-marked horizon along the top of the old quarries on both sides of Meathop Fell, and these two fossils are always found at this horizon in the district, together with the other characteristic species (given below). Mr. Jackson also states that he collected *Reticularia* aff. *lineata* (Martin) from this *Spirifer* bed. This statement, if corroborated, is decidedly important, as I have never found this species in the northern area below the horizon D 2–D 3. It is possible, however, that Mr. Jackson may be mistaken in his identification. Numerous examples of *Athyris glabistria* also occur at this horizon, and as the shells are badly preserved and often fragmentary an accurate determination is not always possible. My collections from the *Spirifer* bed at Meathop contain several other species not previously recorded, the majority of which also occur in the corresponding horizon in the Shap area. The following is a list of forms found in both localities, and shows the close parallelism of the deposits:—

Michelinia megastoma.
Camarophoria isorhyncha.
Syringothyris cuspidata.
Spirifer cf. *furcatus.*
Athyris glabistria.
Derbya sp.
Seminula gregaria, McCoy.
Productus cf. *corrugato-hemisphericus.*
P. cf. *pustulosus.*
Orthotetes crenistria (C 1 var.).
Euomphalus.
Archæosigillaria Vanuxemi (Göppert).
Bellerophon sp.

In addition to these characteristic forms several interesting corals occur which are described in detail in my forthcoming paper.

The beds underlying the *Spirifer* bed at Meathop also contain forms which occur in a similar position below the *Isorhyncha* bed in the Shap area and confirm the correlation here given. It will be sufficient here to mention the occurrence in the lowest beds at Meathop of *Eumetria proava* (Phil.) and *Solenopora* sp., which I have found to characterize the lower portion of the C 1 horizon wherever these beds are exposed in the northern area.

With regard to the plant remains of Meathop, and elsewhere in Westmorland, they are the rule rather than the exception in these lower beds, and may occur at any horizon which happens to be locally near the base of Carboniferous formation wherever the beds were deposited in proximity to a subsiding land surface. Thus they occur near the local base at Meathop, Shap Abbey, Shap Toll Bar, Pinkskey Gill, Hebblethwaite Gill, near Horton-in-Ribblesdale and elsewhere.

Mr. Jackson suggests that *A. Vanuxemi* "may be helpful in arriving at a satisfactory conclusion as to the correct horizon" of the beds which contain it, and adds, "especially when the exact horizon of the plant is known in the North Wales Exposure." I am afraid that I cannot agree with this suggestion; on the contrary I think that any conclusion, based on the occurrence of isolated fragments of plant-remains in the Lower Carboniferous rocks might be most misleading, and might result in serious errors in correlation.

Thus in the present instance *A. Vanuxemi* occurs at Meathop and at two horizons in the Shap district in beds which, as I have shown, belong to the C 1 horizon of the Bristol area, while in North Wales abundant remains of this species occur according to Messrs. Hind and Stobbs in S 2, an horizon very much higher in the series; lastly, this species was originally described from the Upper Devonian of New York. After all, this is only in keeping with what we have been led to expect from the study of the relative duration of terrigenous and marine floras and faunas elsewhere, for instance the Laramie and overlying formations in America.

NOTICES OF MEMOIRS.

Problems of the South-Western Highlands of Scotland. Abstract of the Presidential Address to the Glasgow Geological Society by Professor J. W. Gregory, D.Sc., F.R.S., F.G.S., January, 1910.

The Southern Highlands of Scotland consist of a complex series of gneisses, schists, crystalline limestones and quartzites, trending across Scotland approximately from south-west to north-east. These metamorphic rocks are bounded abruptly to the south by the Highland Boundary Fault, which brings them against Upper Palæozoic rocks. Their northern boundary is less regular and is generally the junction with the Moine Gneiss, the rock which occupies so much of the Northern and Central Highlands. The schists and the associated rocks between the Moine Gneiss and the Boundary Fault may be conveniently grouped together, under the name proposed by Sir Archibald Geikie, as the Dalradian System.

The most important difficulty in the interpretation of these rocks is the uncertainty as to which is the upper and which the lower end of the succession. According to Nicol, the southern members are the youngest, and there is a descending series to the north. This view is contradicted by many obvious facts in the field geology; the view is therefore widely held that Nicol's order must be reversed and that the beds on the southern margin are the oldest. The serious difficulty in the second view is that the southern rocks are much less altered than the northern, and this theory therefore involves some measure of selective metamorphism. Several ingenious interpretations have been advanced to overcome this difficulty. The author of the address, however, held that both views as to the order of the succession are correct in parts.

The Dalradian System is intermediate in age between the Torridon Sandstone above and the Caledonian and Lewisian Gneisses below. That it is pre-Torridonian seems to follow from the evidence in Islay and Colonsay; that it is post-Caledonian is shown by its superposition upon the Moine Gneiss in several localities, as north of Ben Lui and in Glen Tilt; in the latter, the evidence collected by Mr. Barrow appears conclusive that the Dalradians are resting on an eroded surface of the Moine Gneiss. The Dalradian System may be divided into five series as follows:—

Schiehallion Quartzite Series (including the Boulder Bed).
Blair Atholl Series (Limestones, black schists and quartzites).
Ben Lawers Series (Phyllites with some limestones and quartzites).
Loch Tay Series (Limestones, garnetiferous mica schists and some quartzites).
Loch Lomond Series (Gneiss, albite schist, etc.).

The most important rock in the lowest series is the Loch Lomond Gneiss, which is well developed in the peninsula of Cowal, on both sides of the northern part of Loch Lomond, and around Loch Katrine. This series consists mainly of coarse, highly inclined sedimentary gneiss and albite schists. This series extends eastward to Loch Voil, where it disappears beneath the rocks of the Loch Tay Series to the north and the overlap of the Ben Ledi and Ben Vane Grits and slates to the south. North of the Loch Lomond Gneiss occurs a series of garnetiferous mica schists associated with limestones and some quartzites. This series can be traced all across the country; it includes the Glen Daruel limestone south of Loch Fyne, and the limestones of Crianlarich, Glen Lyon, and Loch Tay. That they overlie the Loch Lomond Series is well shown north of Loch Voil, and that they rest unconformably on the Moine Gneiss is proved by the evidence north of Ben Lui. The essential member of the Ben Lawers Series is the phyllite of Ardrishaig, the Forest of Mamlorn and Ben Lawers. This phyllite is often intensely crumpled and seamed with innumerable thin quartz veins. It is associated with thin bands of quartzite and quartz-schist. Its superposition on the Loch Tay series appears to be clearly demonstrated from the relations of the two series at Ben Lawers, and still more clearly from the outliers of the Ben Lawers phyllite resting upon garnetiferous mica schists, as at Ben nam Imirean.

The Blair Atholl Series consists of the Blair Atholl Limestones, the black or graphitic schists and some interbedded quartzites, which are often of considerable thickness and form a large part of the Highland Quartzite. To separate them from the succeeding quartzite, it is proposed to call them the Cammock Hill Quartzite, from a locality where they are well exposed near Pitlochry.

The uppermost member of the Dalradian System is the Schiehallion Quartzite with the boulder bed at its base. It rests unconformably upon the Blair Atholl Series. Parts of the quartzite are quite unfoliated and remain as granular felspathic quartzites, in which the felspar grains have not been sheared or crushed.

According to this arrangement, the five series of the main Dalradian sequence occur in succession from south to north, and the oldest members are the most altered and highly crystalline.

Along the southern margin of the Dalradian schists there is a series of slates and grits, which are not foliated, and strikingly resemble ordinary Palæozoic slates and quartzites. The slates are worked at Luss and Aberfoil. The field relations of these Aberfoil Slates and

Ben Ledi Grits can be most easily explained by their unconformable deposition on the southern edge of the Dalradian rocks.

There has been assumed a transition from the Ben Ledi Grits to the intensely altered gneissic grits belonging to the Loch Lomond series, but the evidence for this passage is not convincing. The southernmost part of these comparatively unaltered rocks include cherts and shales which are marked on the Survey Maps as 'Silurian(?)'.[1] The exact age of these beds is doubtful. They may be Upper Dalradian and correspond to the great unconformity at the base of the Schiehallion Quartzites, or, as is more probable, they may be post-Dalradian in age.

The relations of the Dalradian Schists is suggested as follows:—

Eozoic.	Algonkian . . .	Torridon Sandstone.
	Dalradian.	
	Caledonian . . .	Moine Gneiss and associated schists.
	Lewisian . . .	Fundamental Gneiss.

The classification suggested in the address adopts Nicol's succession in part, as it accepts the Aberfoil and Ben Ledi Series as younger than the Loch Lomond Gneiss against which they rest; and it is consistent with the less altered condition of the southern rocks and the steady diminution in the metamorphism of the rest of the series going northward, as for example, from the Loch Lomond Gneiss to the Loch Awe Grits, and from the garnetiferous mica schists of the Loch Tay Series to the black schists and unfoliated quartzites near Blair Atholl.

The evidence in some points of this succession is still incomplete, especially as regards some of the rocks nearest Glasgow. The special problems on which further research would be most useful were therefore mentioned, in the hope that the members of the Glasgow Geological Society would investigate them.

The subject is of interest from its bearing upon the early geological history and geography of North-Western Europe. The structure of Western Europe has been dominated by the formation of three great mountain systems, each due to pressure usually from the south, and each having its younger rocks exposed mainly on the northern flanks of the chain. The youngest is the Alpine System, formed mainly in Upper Cainozoic times, and including the Pyrenees, Alps, Carpathians, etc. A somewhat similar mountain system, of which fragments remain in Southern Ireland, Devonshire, Brittany and Germany had been formed in Upper Palæozoic times; from its analogy with the Altai Mountains of Asia, Suess has called its mountains the European Altaids. Still earlier, in later Archean times, there was formed the first of these European mountain systems, of which fragments occur in Northern Ireland, the Grampians, and Scandinavia. There are many interesting analogies between these old Grampians and the later Altaids and Alps. The old mountain system to which the Grampians belonged probably extended far westward into the North Atlantic and to its influence may be attributed the desert climate of Scotland during the deposition of the Torridon Sandstone.

[1] By kind permission of Dr. Horne it was announced during the address that Dr. Hinde has recently identified Radiolaria in the cherts of this series.

REVIEWS.

I.—Radioactivity and Geology: an Account of the Influence of Radioactive Energy on Terrestrial History. By J. Joly, M.A., Sc.D., F.R.S. 8vo; pp. xi + 287. London: A. Constable and Co., Ltd., 1909. Price 7*s.* 6*d.*

THE developments which have followed so rapidly upon the discovery of the wonderful properties of radium have caused something like a revolution in more than one branch of physical science. How much these new developments concern geologists was first brought home to most of us by Professor Joly's address at the Dublin meeting of the British Association in 1908. The volume before us is an expansion of that address. In it the author marshals the results of researches, to which he has largely contributed, concerning the distribution of radium in igneous rocks, in sediments of different kinds, and in various waters. From the results thus brought together he deduces consequences of great moment, which are pursued, in successive chapters of the book, through all the ramifications of dynamic geology.

The variety of subjects which are passed in review, and the fact that they are presented as parts of an organic whole, make it difficult to do justice to Professor Joly's work in a brief notice. Indeed, it is scarcely possible to summarize what is in effect one extended chain of arguments resting on numerical data. It makes us see from a new point of view the complex interaction which unites the varied operations of inorganic nature. We are familiar, for instance, with the conception of a cycle of events: sedimentation leading to gradual subsidence of an area under the growing load, the heating of the depressed rock-masses causing upheaval and folding, finally erosion coming into play, with transportation and renewed sedimentation in an area adjacent to the former. Viewed in the light of the radium-content of the sediments, this assumes a new aspect. "The energy . . . is in fact transported with the sediments—the energy which determines the place of yielding and upheaval, and ordains that the mountain ranges shall stand around the continental borders. Sedimentation from this point of view is a convection of energy" (chap. v). In the following chapter the author endeavours to trace a like relation between the instability of the ocean floor and the radioactivity of oceanic deposits.

In a book treating of a field so wide and so little explored there is necessarily much which must be regarded as debatable. That the radioactive processes are not controlled by temperature or pressure is a thesis so remarkable that we are entitled to ask for very cogent evidence of it. Some experimental data bearing on this point are cited, but they do not apply to the breaking up of the parent uranium, upon which the whole train of transformations depends. If we can suppose this process to be checked by rise of temperature, Professor Joly's argument concerning the relation of underground temperature to radioactivity will require revision. It will be no longer necessary to assume that the heavy element uranium is accumulated in the outer layer of the globe, an arrangement which the author explains in a manner not very convincing.

Many readers will turn expectant to the chapter on "Uranium and the Age of the Earth"; but here we must confess some degree of disappointment. From comparative determinations of radium and helium, especially in phosphatic nodules,[1] Strutt has arrived at high estimates of the age of the stratified sequence. Since the most likely source of error is loss of part of the helium, these should be under- rather than over-estimates. Our author cites these and some other results, but only to emphasize the elements of doubt attaching to them. He then throws over radioactivity, and offers us, instead, two methods of calculating geological time which lead to very much lower figures. One is based on the rate of sedimentation, and the other on the amount of sodium in the sea. Both have already been before the geological public, and it is not necessary to enter into them. To us they appear far more hazardous than the helium method.

The manipulation of figures possesses an undoubted fascination. There is a feeling of security in striking a mean of discordant results, and a certain sense of generosity in allowing a margin on the side of safety; and it is easy for the enthusiastic speculator to forget how enormously errors may accumulate when several rough estimates are taken as links in a chain of argument. Even the taking of a mean demands more judgment than it sometimes receives. For instance, on p. 234 of this book, we are given the ratio of sediment carried in the waters of nine different rivers. This ratio ranges from 1 in 291 to 1 in 10,000. We do not believe that an average of nine figures so discordant can afford any useful information concerning the average amount of sediment carried by the rivers of the world. But, further, the author has taken a harmonic instead of an arithmetic mean. The true mean is not 1 in 2731, but 1 in 1182, which at one blow reduces the calculated eighty millions of years to about thirty-five millions! Personally we do not attach any weight to one or other of these figures.

We are far from wishing to disparage the introduction of quantitative considerations into dynamical and historical geology; but we feel at the same time the need for sounding a note of warning at the present juncture. Thanks to the discovery of radium, geology is finally delivered from the tyranny of a certain school of physicists, and Lord Kelvin's arguments based upon the *consistentior status* are swept away. Let us take heed lest, freed from one bondage, we fall straightway into another not less galling.

Probably Professor Joly does not look for unhesitating acceptance of all his conclusions. However much opinions may differ on some of the points raised, he has here introduced us to a large number of important and curious questions, and his book should be in the hands of every geologist who is interested in the modern developments of science.

A. H.

[1] Strongly confirmed, since this was written, by examination of zircons from igneous rocks of various ages.

II.—Geology in the Field. The Jubilee Volume of the Geologists' Association (1858–1908). Edited by H. W. Monckton and R. S. Herries. Part II: pp. 210–432, with 8 plates. London: Edward Stanford. 1910. Price 5*s.* net.

IN December last we drew attention to the publication of Part I of this work, and we are glad to note that a copious index is promised at the conclusion of the fourth part. The work is a more or less complex one, dealing sometimes with the geology of particular counties, at others with irregular districts, and again with particular formations in certain areas. The whole has been most carefully edited by Messrs. Monckton and Herries, whose task must have been no light one. The records of previous excursions made by the Geologists' Association form the basis of the work, and there are abundant references to the published proceedings, although the names of the responsible directors of excursions are not always indicated.

In the present part, "Berkshire and part of the Thames Valley" forms the subject of an article by Mr. H. J. Osborne White. He deals with strata from the Oxfordian to the Alluvial deposits. A useful sketch-map is given of the neighbourhood of Faringdon, showing the position of the pits in the famous sponge-gravel beds of the Lower Greensand.

"North Kent and adjoining parts of Surrey" are next described by Mr. A. L. Leach, who, after a brief reference to the Chalk, the Chislehurst Caves and Dene-holes, describes the principal sections in the Eocene strata, notes the Pliocene Beds of Lenham and elsewhere, and concludes with a short account of the superficial deposits and successive types of stone-implements.

"The Chalk Cliffs of Kent and Sussex and the Tertiary Beds of Herne Bay" are described by Mr. G. W. Young, with due references to the labours of Mr. Whitaker and Dr. Rowe, in whose footsteps Mr. Young has so successfully trodden.

"The Tertiary and Post-Tertiary Deposits of the Sussex Coast" are dealt with by Mr. J. V. Elsden. Newhaven, Bognor, and Selsey Bill come in for notice in connexion with the Eocene strata, while the Coombe Rock and other superficial deposits are discussed. The author remarks that the bottom of the Arun Valley is now considerably below sea-level.

"Hampshire and the Bagshot District" come into the appropriate hands of Mr. Monckton and Mr. Osborne White, who deal with the Chalk and Eocene, and especially with the Bagshot, Bracklesham, and Barton Beds.

"Wiltshire" is described by Mr. H. B. Woodward, who gives brief accounts of the famous sections in strata that range from Lias to Purbeck and Wealden, and from Lower Greensand to Chalk and Eocene, with superficial deposits of much interest. Reference is made to Mr. Harmer's 'Glacial Lake' in the Trowbridge Basin.

"The Palæozoic Rocks of Gloucestershire and Somerset" form the subject of an article by Professor S. H. Reynolds, who has added so much to our knowledge of the Tortworth Silurian area, and has discovered fossiliferous strata, probably of Llandovery age on the

Mendips. The associated volcanic rocks, the Old Red Sandstone and its fish-remains, and the zones in the Carboniferous Limestone Series are more particularly described, brief references only being made to the Coal-measures.

"The Neozoic Rocks of Gloucestershire and Somerset," including accounts of various formations from the Bunter to the Chalk and superficial deposits, are described by Mr. L. Richardson. As might be expected more details are given of the Rhætic Beds, with their basal grey marls, termed Sully Beds, that have yielded *Avicula* [*Pteria*] *contorta* and *Ostrea Bristowi*; of the Lias and Inferior Oolite and their 'hemeræ'. The geological history after the Cretaceous Period is briefly sketched, and full references are given to the literature of the Drift deposits.

"Dorset—Inland" is the title of an article contributed by the late W. H. Hudleston, and it is prefaced by a list of names of fossils and zones adopted by him, with remarks upon them, drawn up at his request, by Mr. S. S. Buckman. We must confess to a preference for the names used by Mr. Hudleston, whose judgment on these matters was always philosophic, sound, and practical. The principal sections in the Inferior Oolite near Sherborne and Yeovil are described; and an account is given of the Wareham District, with particulars of the well-boring at Bovington, and of the outlier of possibly Bembridge Limestone, discovered by the author at Creechbarrow Hill.

"The Dorset Coast" is described by Mr. Monckton, who deals with the strata visited during excursions made to Lyme Regis, Bridport, Weymouth, Abbotsbury, and the Isle of Purbeck.

"The Isle of Wight" is dealt with by Mr. Herries, who has given a concise account of the physical features and geology of this oft-visited geological paradise.

There is therefore plenty of interesting and instructive material to be found in this part of "Geology in the Field", and it will be of essential service to all who visit the districts described.

III.—A Treatise on Zoology. Edited by Sir Ray Lankester, K.C.B., M.A., LL.D., F.R.S. Part IX: Vertebrata Craniata (First fascicle: Cyclostomes and Fishes), by E. S. Goodrich, M.A., F.R.S. London: Adam & Charles Black, 1909. 8vo; pp. xvi+518, with 515 text-figures. Price 15*s.*

THIS volume, like the others of the series to which it belongs, is devoted to morphology and classification; it contains valuable and well-written accounts of the general characters of the Craniate Vertebrates, of the Cyclostomata and Gnathostomata, of the Fishes, and of the two main branches of the last-named, the Chondrichthyes and Osteichthyes; the results of Mr. Goodrich's recent important researches on the exoskeletal structures of fishes and on the origin of limbs are here included.

The morphological parts of the book suffer a little from compression, and from the paucity of references to function. The statement that the jaws developed from the first pair of visceral arches might have been qualified, for the labial cartilages may reasonably be interpreted as the remnants of præ-mandibular arches.

The arrangement of the Selachians (*Chondrichthyes*) differs from most recent systems in the recognition of only four primary groups, the Holocephali and Euselachii (Selachii of Goodrich) being united to form a division co-ordinate with the Ichthyotomi, Pleuropterygii, and Acanthodii. In a natural system the two last-named should be placed first, the structure of their paired fins and the absence of mixopterygia indicating their generalization; of the other three orders, or sub-classes, characterized by the presence of mixopterygia, the Holocephali are quite as distinct from the Euselachii as from the Ichthyotomi; the presence of a pharyngo-hyal shows that their autostyly is not a modified hyostyly, and Mr. Goodrich has failed to recognize that in the Selachians the terms 'hyomandibular' and 'epihyal' are synonymous, and that the hyoid arch of the Chimæroids is essentially similar to the succeeding branchial arches.

The classification of the modern Sharks and Rays is marred by some erroneous diagnoses and unnatural groupings; for example, the Lamnidæ are said to have no oro-nasal grooves, wide gill-openings, a pit at the base of the caudal fin and a keel on each side of the tail, and they are made to include *Alopias*, which has small gill-openings and no caudal keel, the Odontaspidæ, without or with vestigial pit and without keel, and *Rhinodon*, which differs from them *in toto* in the presence of oro-nasal grooves, the position of the gill-openings above the pectoral fin, etc., and indeed belongs to the Orectolobidæ, which family our author unites with the very different Scyliorhinidæ (Scylliidæ).

The Chondrichthyes are followed by the Ostracodermi, a provisional group; here some of Dr. Traquair's recent interesting discoveries from the Silurian of Scotland are described and figured, and his views as to the relationship of the Cœlolepidæ, Psammosteidæ and Drepanaspidæ are confirmed by Mr. Goodrich's demonstration of the structural similarity of their exoskeleton. A new restoration of *Cephalaspis* calls for comment, as the organs shown by Dr. Smith Woodward to be 'opercular' prolongations of the head-shield, are figured and described as scaly, fin-like lobes, narrowed at the base, and projecting from each side of the body behind the head-shield; we venture to think that there is no justification for this interpretation.

The Osteichthyes are divided into two main branches, the Dipnoi (with which the Arthrodires are provisionally associated), and the Teleostomi; it is not a little singular that this arrangement should be maintained by Mr. Goodrich, whose embryological researches have confirmed the secondary nature of the so-called 'archipterygium', and who first described the similar structure of the Osteolepid and primitive Dipnoan scales and fin-rays, and the nearly normal arrangement of the bones of the cranial roof in Dipnoan genera such as *Phaneropleuron* and *Ctenodus*.

The Dipnoi indeed scarcely differ from the Osteolepida except in their autostyly, and as this is plainly a modified hyostyly, from the structure of the hyoid arch, they should follow that group in a natural system. The modern Dipnoans are said to have internal nares, but as a matter of fact the nostrils are merely labial, as in some Eels (*Ophichthys*), and the posterior ones cannot be homologized with true internal nares. Mr. Goodrich thinks that the nostrils were ventral in the Osteolepida; this can scarcely have been the case in fishes with a terminal mouth and marginal dentition, and in which (as in *Cricodus*) the small nasal pits were antero-lateral.

The Crossopterygii follow the Dipnoi, and lead through *Polypterus* to the Chondrostei; the highly specialized present-day members of the last-named group still retain many features of generalization, notably in the paired fins, and they can be traced back step by step to the palæozoic Palæoniscidæ, in our opinion the most primitive of all Teleostomes, in which the pelvic fins had an extended base, and were supported, as in the modern *Psephurus*, by a series of parallel pterygiophores. Mr. Goodrich has shown that *Polypterus* agrees with the Palæoniscidæ in scale structure, and this confirms the evidence derived from the paired fins, that the recent genus is not descended from the Osteolepida, but from more generalized Crossopterygians.

In the classification of the Mesozoic fishes of the Actinopterygian series Mr. Goodrich follows Dr. Smith Woodward, except that he makes the Amioids equivalent in rank to the Teleosts, and by placing the Oligopleuridæ and some allied families in the former renders neither group definable. The classification of the Teleosteans is based on that of the "Cambridge Natural History", but the best feature of that system, its simplicity, has been lost. A number of new, and often unnatural, divisions are established, many of which are merely designated Super-family I, Branch A, Sub-tribe B, etc., and when names are given they only confuse matters still more. Thus the Cypriniformes are a sub-order, the Lampridiformes a division, the Zeorhombiformes a subdivision, the Perciformes a tribe, and the Chætodontiformes a sub-tribe, whilst the termination *oidei* is also used for a number of groups of unequal rank. In addition to the Siganidæ (Teuthididæ of Günther) and the Acanthuridæ (Teuthididæ of modern authors) a family Teuthididæ is included and diagnosed which has no actual existence. The interposition of the Plectognathi between closely related families such as the Serranidæ and Centrarchidæ, and of the Ostariophysi between the Leptolepidæ and Elopidæ, cannot easily be justified; it would be paralleled by the intercalation of the Marsupials between *Ornithorhynchus* and *Echidna*.

The illustrations are numerous and on the whole well-executed. Mr. Goodrich's original restorations of the crania of some extinct Dipnoans, and his diagrammatic sections illustrating scale structures are especially interesting. One of the least satisfactory figures is that of the caudal fin of the cod, for it does not show that most of the rays, except the few attached to the reduced hypural, are inserted each on its own basal support; the latter are about twice as numerous as the neural and hæmal spines, with which about half of them are ankylosed, whilst the rest remain distinct or unite with the neural and hæmal spines by suture. This structure, clearly seen in *Gadus virens* and *G. morrhua*, is probably characteristic of all the Gadidæ.

A useful bibliography concludes the book, which, on the whole, does not compare favourably with some of the others in this series; for whilst the general chapters reach the high level expected of a zoologist of Mr. Goodrich's reputation and experience, the systematic portions, in the case of some of the recent groups, indicate that he is not thoroughly acquainted with the animals about which he is writing.

C. T. R.

IV.—British Fossils. Monographs of the Palæontographical Society,[1] 1909, vol. lxiii.

THE beautifully illustrated works on British fossils published by the Palæontographical Society still appear with their wonted regularity. There is no lack of valuable material, and palæontologists who have opportunity for pursuing extended researches are glad to avail themselves of the facilities for the adequate illustration of their writings afforded by the Society. It is only to be regretted that the annual volume shows a tendency to reduction in size, owing to the recent death of numerous old subscribers and the tardiness of the new generation in taking their places.

The volume for 1909 opens with another instalment of the Monograph of British Pleistocene Mammalia by Professor S. H. Reynolds. This year he deals with the Canidæ, and publishes a fine series of illustrations of the skulls and teeth of the wolf, Arctic fox, and common fox. The text is disappointing and scarcely does justice to the subject; but the measurements and drawings will be very useful to collectors for identification of their specimens. Dr. A. S. Woodward follows with the fifth part of his Fossil Fishes of the English Chalk, treating of the Ganoids (except *Protosphyræna* and *Belonostomus*, which were described in the previous year). Some of the remains are very fragmentary and hardly worth description; but the unique collection of *Macropoma* from the English Chalk has afforded the opportunity for a valuable new contribution to our knowledge of the Cœlacanthidæ. A drawing of the restored skeleton of *Macropoma*, by Miss G. M. Woodward, is included. Dr. Traquair contributes another instalment of his important memoir on the Carboniferous Palæoniscid Fishes, with a fine series of plates. He writes chiefly of *Acrolepis* and *Nematoptychius*, and adds drawings of *Rhadinichthys*, which are presumably to be described in the next part. *Acrolepis Hopkinsi* appears to occur above and below the Millstone Grit—an unusually extended distribution. Mr. Henry Woods provides the largest section of the volume in another part of his well-known Monograph of Cretaceous Lamellibranchia, which makes excellent progress. This year he deals with the Solenidæ, Saxicavidæ, Pholadidæ, Teredinidæ, Anatinidæ, Pholadomyidæ, Pleuromyidæ, Poromyacidæ, and Cuspidariidæ. It is a most laborious work, on account of the extensive literature which has to be digested while the fossils are studied; but it is evidently done with thoroughness. The volume concludes with title-pages and indexes for Sharp's Mollusca of the Chalk and Phillips' British Belemnites, which were left unfinished by the death of the authors many years ago.

[1] Annual subscription, which entitles to membership, £1 1*s*., due January 1. Apply to the Secretary, Dr. A. S. Woodward, F.R.S., British Museum (Nat. Hist.).

V.—Brief Notices.

1. Soils of South Africa.—Dr. C. F. Juritz, in his Presidential Address to Section 2 of the South African Association for the Advancement of Science, on September 29, 1909, has some pertinent remarks on this subject. After sketching the general lines of soil investigation, he states: "We have not been able to do all this in the Cape Colony, because the entire work of investigating the Colony's soils has always been allocated to one solitary man, and even then it has been subject to constant interruption." He proceeds to point out what is done in the United States, and shows that the original staff of 10 men (not one man) had, ten years after its establishment, increased to 127 men, including 83 scientists and soil experts, 13 tobacco experts, and 29 clerks and other employés, and still was found inadequate for one-half the demands made upon it for investigations along its special lines. Dr. Juritz, quoting the official publications, points out that extraordinary increases in land value have followed the work of the Bureau of Soils in the United States. Soils in the Connecticut Valley, which the Bureau showed were adapted for growing a superior tobacco, increased in value threefold. Trucking soils of the Atlantic seaboard have risen from 5 dollars an acre to 200 dollars; rice lands of Louisiana from 5 to 50 dollars; and Florida patches, specially adapted for growing pine-apples, from nothing to over 500 dollars an acre. Upon these facts and many others Dr. Juritz comments: "Has not the time arrived for this important subject to be tackled in right earnest in our own South Africa instead of continuing merely to be toyed with?"

2. Soils of Hungary.—For many years the study of the soils of Hungary has occupied a number of her best investigators, and in February last year the Royal Hungarian Geological Institute (*Magyar kiralyi Földtani Intézet*) issued invitations for a Conference of Agrogeologists to meet in Budapest. This was, we believe, the first Agrogeological Congress, and the report of its deliberations is now before us as *Comptes Rendus de la première Conférence Internationale Agrogéologique.* The volume consists of 334 pages and has a soil map of Roumania with an inset map of the climatic zones of the same country. Sixty-nine pages are devoted to the reports of the meetings of the Congress, twenty to the excursions made to Hidegkut, Gödöllö, the Great Plain (Alföld), and to Lake Balaton; and the remainder of the volume is occupied by papers on various subjects as follows:—Soils of European and Asiatic Russia, by Glinka; Soils of Norway, by Björlykke; Daily Weathering in the light of Colloidal Chemistry, by Cornu; What is Weathering? by Treitz; Climatic Zones of Soils, by Cholnoky; Special Exigences of Agriculture with regard to Analyses of Soils, by Leplae; Methods of Soil Analysis in the Prussian Survey, by Schucht; Agrogeological Maps, by Timko and Güll; Agronomical Work in Bohemia, by Kopecky; Chemical Analyses of Soils, by Emszt and Sigmond; The Körös Floods, by Ujj; Soda-holding Soils, by Sigmond; Ampelogeological Maps, by Dicenty; Lime-holding Soils, by Treitz; Mineral Soils, by Atterberg; Unification of Methods of Chemical Soil Analyses, by Hilgard; and the Soils of Roumania, by Murgoci.

3. The Wakatipu District, New Zealand.—Professor James Park, in his Presidential Address to the Otago Institute, 1909, on the origin and history of the Wakatipu District, deduced from the facts observed by him in the course of his survey that probably in the Pleistocene Period the southern portion of the South Island of New Zealand had been covered by an ice-sheet, some 7500 feet in thickness. That is to say, there has been an Ice Age in New Zealand similar to that in the Northern Hemisphere.

4. The Temperature of the Earth and Earth-movements.—The Government of New Zealand has placed £200 at the disposal of the Philosophical Institute of Canterbury, New Zealand, to enable that body to investigate the temperature of the earth's crust and other geophysical and geological phenomena rendered possible by the construction of the Arthur's Pass Tunnel. It is further announced in the Proceedings of the New Zealand Institute that the Government are taking practical steps to erect bench-marks at suitable places along the coast.

5. The Tertiary Beds of North-West Germany.—Dr. A. v. Koenen has brought together the latest information on the Tertiary of North-West Germany originally investigated by Beyrich fifty years ago. His pamphlet (2 *Jahresber. Niedersächsischen geol. Ver. zu Hannover*, 1909) sketches the Palæocene, the Oligocene, and the Miocene, and gives a list of fossils from Volpriehausen, with annotations as to similar occurrences in the Scaldisian and the English Crag.

6. The Geology of the Waterberg Tin-fields, by H. Kynaston, E. T. Mellor, and U. P. Swinburne, forms No. 4 of the Geological Survey Memoirs of the Transvaal Mines Department, 1909. The ore occurs as Cassiterite. The geological structure of the country is comparatively simple. The central plateau is formed of the Upper Sandstones of the Waterberg system and the outer rim by the high ranges of granite and felsite which form the watershed between the Stark River and the Nyl and Magalakwin. Excellent coloured maps and sections accompany the paper.

7. The Copper, Tin, and Silver Deposits of Pitkäranta on Lake Ladoga form the subject of the *Bulletin de la Commission Géologique de Finlande*, No. 19 (November, 1907). The report is written by Otto Trüstedt, and occupies 334 pages. Many figures of rock-structure are given, and several plates are devoted to illustrating "Eozoon-Serpentine Zones". There is a coloured map, a table showing the output of the mines since 1814, and a list of all minerals recorded.

8. The Miocene of Astoria and Coos Bay, Oregon (U.S. Geol. Surv., Prof. Paper 59, 1909).—Dr. W. H. Dall has reprinted twelve papers by previous authors on the same subject because of their inaccessibility to students living in the Pacific States. Happy students! And generous Government! The work itself is produced in Dr. Dall's customary careful style, and is well illustrated by twenty-two plates of fossils, text-figures, and map. Many new forms are described, the validity of several genera is discussed in detail, and a further description of the fossil sea-lion (*Pontolis magnus*), by F. W. True, is appended, and illustrations of its skull are given.

9. The Gotlandian of Fyledal.—Professors J. E. Moberg and K. A. Grönwall have contributed to *Meddelande från Lunds Geologiska Fåltklubb* (ser. B, No. 3, 1909) a paper on the Gotlandian of Fyledal. The beds are rich in the genus *Bellerophon*, and contain numerous ostracoda of a familiar type to those who work in similar English deposits. Thus of nineteen forms described seven or eight are identical with those recorded from the Upper Silurian of England by Jones and others.

10. New Zealand Geological Survey.—From the geology of the Whangaroa subdivision, Hokianga division, by J. M. Bell and E. de C. Clarke (Bull. N.Z. Geol. Surv., No. 8, 1909) we learn that the beds exposed in their area are pre-Cretaceous, late Mesozoic, Eocene, Miocene, and recent, with much intrusive and other igneous rock of doubtful age. Fossils are found of Cretaceous age, but they are imperfectly preserved and difficult to clean owing to the hardness of the matrix. They include *Trigonia*, *Desmoceras*, *Hamites*, *Ostrea*, and *Oxyrhina*, and these are said to be insufficient, even with other fragmentary remains, to allow of correlation with the other New Zealand Mesozoic beds. The igneous series are described in much detail, and numerous micro-sections of the rocks are given. The economic geology includes notes on cupriferous sulphides, mercury ores, precious metals, iron, manganese oxides, kauri-gum, oil, building and cement stones, mineral waters, and sulphur. A list of minerals met with, and a glossary of scientific and mining terms used in the report, are appended.

11. A Fossil Horse in South Africa.—Dr. R. Broom, among several Reptilian papers in the Annals of the South African Museum (vol. vii, pt. iii, April, 1909), calls attention to the evidence in favour of the existence of an extinct horse in South Africa. Three specimens have now been found, and the last "makes it pretty certain that a very large horse was a native of South Africa before European occupation". In a slab of the coast-limestone cast ashore at Yzerplaatz is the greater part of the lower jaw of a large horse. This he now calls *Equus capensis*. The third premolar shows no trace of the rudimentary protostylid as compared with that of the modern horse. Teeth of a horse were described by Fraas from South Africa in 1908, and on May 11, 1909, Professor Ridgeway showed a portion of the fossil jaw of one of the Equidæ from Naivastra, German East Africa, to the Zoological Society of London.

12. Fossil Vertebrates of the Karroo, South Africa.—In the same number of the Annals of the South African Museum, Dr. Broom makes an attempt to determine the horizons of the fossil vertebrates of the Karroo. In drawing up the table he has ignored types founded on vertebræ or fragments of skeletons, as most of these are probably portions of animals already known from their skulls.

13. Distribution of Iron Ores in Egypt.—Dr. Fraser Hume discusses the Distribution of Iron Ores in Egypt, in Survey Department Paper No. 20 (Ministry of Finance, Egypt, 1909). Southern Sinai, the N.E. and S.E. deserts, the oases, the ferruginous beds in the Nubian

Sandstone, Sudan, Darfur, Kordofan, and Abyssinia are all referred to, and a map is given showing the distribution. The iron of Egypt does not appear to be of much commercial importance, but that of Darfur and Kordofan may possibly be worth attention in future.

14. Cretaceous of Pondoland. — With regard to the age of the Cretaceous rocks of Pondoland and those of Port Durnford to beyond St. Lucia Bay, it has been shown by Mr. Henry Woods (Ann. South African Mus., iv (7), December, 1906) that they are the equivalent of the Campanian (Upper Senonian) of Europe, the Ariyalur Beds of Trichinopoli, and the Valudayur and Trigonoarca Beds of Pondicherri. Deposits of a similar age have been shown to occur in Madagascar. Griesbach supposed that five faunas could be recognized in successive zones of these African deposits, and correlated the uppermost with the Greensands and the White Chalk of England. Later on, Rogers and Schwarz showed that the fauna was more generally distributed vertically than Griesbach had supposed, and belonged to one deposit. Woods' work confirms this, and proves that only one zone is represented.

15. The Phosphate Deposits of South Carolina and New Brunswick. By G. F. Matthew, LL.D., F.R.S.C. Bull. Nat. Hist. Society of New Brunswick, vol. vi, pt. ii, p. 121.—This is a brief account of a visit to the deposits on the rivers of South Carolina, from which so much calcium-phosphate has been obtained of late years, chiefly in the form of bones and teeth of extinct forms of vertebrates taken from layers under the river beds of those streams. The remains are of various ages, from the Eocene upwards, but have been rolled in the sea and redeposited in beds, which contain many recent shells and so are comparatively modern. These recent deposits are compared with the vastly more ancient Cambrian phosphates of New Brunswick, which have been accumulated under somewhat similar conditions. In these last-named beds the phosphatic nodules are mingled with Brachiopod shells and the detached portions of the heads and body-segments of trilobites.

16. Geological Time.—In an article on "The Accumulation of Helium in Geological Time" (Proc. Roy. Soc., 1909, ser. A, vol. lxxxiii, p. 96) the Hon. R. J. Strutt gives the results of investigations among iron-stones which contain helium. He remarks that the results on hæmatite from co. Antrim are especially noteworthy, as it would appear that the Eocene period must be put back thirty million years.

17. Royal Scottish Museum, Edinburgh.—A useful *Introduction to Petrography and Guide to the Collection of Rocks* in the museum has been prepared by Dr. S. J. Shand (pp. 50, 1909), and is sold at the price of one penny. It deals with the Igneous, Sedimentary, and Metamorphic rocks, and contains introductory remarks on the nature and genesis of rocks, and on the general character of minerals. Moreover, it has a good index.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

January 12, 1910.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "On the Igneous and Associated Sedimentary Rocks of the Glensaul District (County Galway)." By Charles Irving Gardiner, M.A., F.G.S., and Professor Sidney Hugh Reynolds, M.A., F.G.S.; with a Palæontological Appendix by Frederick Richard Cowper Reed, M.A., F.G.S.

The general succession of the rocks of the Glensaul district is as follows, in descending order:—

	Thickness in feet.
3. ? Bala Beds. Conglomerates and Sandstones. These beds have not been studied.	
2. Shangort and Tourmakeady Beds.	
(8) Calcareous gritty tuff of no great coarseness, sometimes becoming so calcareous as to pass into fairly pure limestone, enclosing also bands and patches of limestone breccia, and, more rarely, bands of highly fossiliferous limestone which in some cases has been shattered by earth-movements.	
(7) Very coarse tuff or breccia, mainly composed of felsite fragments: associated with it are impersistent bands of fine tuff . .	750
(6) Tuff, coarse and fine, with occasional patches of calcareous beds, and at one point graptolitic beds indicating the zone of *Didymograptus hirundo*	150
(5) Great felsite sill of Tonaglanna and Greenaun . . about	1100
(4) Coarse grit	20
(3) Gritty tuff . . . . . . varying in thickness from	520 to 620
(2) Coarse tuff or breccia, mainly composed of felsite fragments .	75
(1) Fine banded tuff	55
1. Mount Partry Beds.	
(4) Coarse grits	150
(3) Fine grits and tuffs associated with black chert, graptolitic beds, and a prominent band of coarse tuff or breccia about 30 feet thick. The graptolites indicate the zone of *Didymograptus extensus*	(?) 150
(2) Coarse grits	110
(1) Coarse conglomerates, about 600 feet seen.	

The graptolitic beds occurring in Band 3 of the Mount Partry Beds have yielded nineteen species, which have been determined by Miss G. L. Elles, D.Sc., who considers that they indicate the upper part of the zone of *Didymograptus extensus*. The commonest species met with are *D. extensus*, Hall, and *D. bifidus*, Hall, both species being represented by small mutations. Rounded bodies, which a comparison with the better preserved specimens from the Tourmakeady district shows to be almost certainly Radiolaria, were noted in sections of the cherts and shaly beds at several points.

In a previous description of the rocks of the Tourmakeady district, the term Shangort Beds was applied to a series of grits and tuffs, and the term Tourmakeady Beds to an associated series of calcareous strata which generally take the form of limestone breccias. In the

Glensaul district it is not possible to draw a sharp line of distinction between the two rock-types, some of the calcareous gritty tuffs passing into nearly pure limestone; but the authors retain the terms to indicate the close connexion between the two districts.

The fossils from the Shangort and Tourmakeady Beds, which have been examined by Mr. F. R. Cowper Reed, show a close resemblance to those of the Tourmakeady district; but the finding of certain additional forms, especially *Nileus armadillo* and *Niobe* sp., has impressed upon Mr. Reed the close connexion between this fauna and that of the *Orthoceras* Limestone of Sweden, and has convinced him that it is rather of Arenig than of Llandeilo age. The conclusion is in conformity with the field-evidence, for at one point beds of gritty shale, containing Radiolaria and Graptolites (indicating the zone of *Didymograptus hirundo*), occur associated with the tuff of the Shangort Beds. The relegation of the Shangort and Tourmakeady Beds of Glensaul to the Arenig would imply a similar age for those of the Tourmakeady district.

The Glensaul district contrasts strongly with that of Tourmakeady as regards the character of the crystalline igneous rocks, which are all quartz-felsites, and the authors believe them to be entirely intrusive.

Mr. F. R. C. Reed describes one species of *Illænus*, one of *Niobe*, one of *Nileus*, two of *Bathyurus*, three of *Cheirurus*, one of *Pliomera*, one of *Encrinurus*, one of *Phacops*, and a new species of *Bathyurellus*. He also describes three species of *Orthis*, one of *Hyolithes*, one of *Rafinesquina*, one of *Camerella*, and one of *Porambonites*, and his conclusions as to the evidence which is furnished by the fauna regarding the age of the beds are mentioned above.

2. "On the Gneisses and Altered Dacites of the Dandenong District (Victoria), and their Relations to the Dacites and to the Granodiorites of the Area." By Professor Ernest Willington Skeats, D.Sc., A.R.C.S., F.G.S.

The area described lies about 25 miles south-south-east of Melbourne. The earlier literature is discussed, and it is shown that the early geological surveyors regarded the dacites as Palæozoic 'traps' passing gradually into the granodiorites. Professor J. W. Gregory first described the rocks as dacites, probably of Lower Tertiary age, resting upon the denuded surface of the granodiorites and of the adjoining Lower Palæozoic sediments. The author describes the field-relations of the rocks, and shows that gneiss occurs between the dacite and the granodiorite in places. Elsewhere at the contact the dacite appears slightly altered. The contact with the plutonic rock is everywhere abrupt. No foliation or banding occurs in the granodiorites, but acid veins pass from the junction into the altered dacite and also cut across the foliations of the gneiss. The field evidence, therefore, shows that the dacites are older than the granodiorites, and also that the gneiss was formed before the intrusion of the acid veins. Chemical analyses of the rocks and of the coloured minerals of the dacites are recorded.

The chemical evidence indicates that slight differentiation of a magma took place: the dacite was first erupted, and, following shortly on that, the granodiorite (of slightly more acid composition) was intruded into the dacite. The microscopic characters of the granodiorite, the dacite, the altered dacites, and the gneiss are described. In the altered dacites a slight banding or schistosity occurs near the contact, ilmenite is changed to secondary biotite by reaction with the felspar in the microgranular groundmass, biotite is corroded by the attack of the groundmass, and hypersthene is altered at its margin to secondary biotite and secondary quartz. Finally, minute granules of blue tourmaline occur in the contact rocks. All the changes enumerated above are attributed to contact-metamorphism caused by the intrusion of the granodiorite.

In the gneiss, hypersthene is not found, ilmenite is rare, and the rock is completely foliated. It shows a granular groundmass similar to, but coarser in grain than, the groundmass of the dacite. Besides occurring at the contact, it has also been found in parallel zones intercalated in dacite near the contact.

The author believes that the gneiss is a peculiar modification of the dacite, but direct evidence as to its mode of origin is as yet incomplete. It may possibly be the result of extreme contact-metamorphism of a dacite of peculiar character, such as a tuff. It is possible that it was produced by differential movement in the dacite before complete consolidation, and certainly before the intrusion of the granodiorite. Since, however, dynamic effects are present in some sections, and are accompanied by changes found in the dacites altered by contact-metamorphism, the author is rather inclined to support the view that primarily the gneiss is due to differential movements in part of the dacite series, complicated by effects due to contact-metamorphism by the later intrusion of the granodiorite.

3. "Recent Improvements in Rock-Section Cutting Apparatus." By H. J. Grayson, Demonstrator of Petrology and Assistant in the Geological Department, University of Melbourne. (Communicated by Professor E. W. Skeats, D.Sc., A.R.C.S., F.G.S.)

The apparatus described has been designed and constructed by the author, for use in the University of Melbourne. It comprises a slitting disk of mild steel and two bronze grinding laps, mounted on a very substantial wooden table. The disks and laps are each 10 inches in diameter, and revolve at about 900 revolutions a minute. The disks and laps are connected with endless belts, which in turn are connected with wheels driven by a 1 horse-power electric motor. Special clamps are used to attach the rock-specimen and to cut the slice. A goniometric crystal-holder, permitting of slicing in any desired direction, is described, and can be fitted to one of the clamps. Clamps swinging radially across the grinding laps permit the parallel grinding of the slice to any required thinness. A polishing lap can be placed in the position of one of the grinding laps. The finishing of the slice is done by hand on a slate disk. In the second part of the paper the author describes in detail the method which he employs in making a rock-section, and refers to a number of improved methods or variations of the usual processes which he has in practice found advantageous.

January 26, 1910.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "On a Skull of *Megalosaurus* from the Great Oolite of Minchinhampton." By Arthur Smith Woodward, LL.D., F.R.S., F.L.S., Sec. G.S.

The specimen was discovered and prepared by Mr. F. Lewis Bradley, F.G.S., and shows for the first time the skull of *Megalosaurus*. It agrees closely with the Megalosaurian skulls of other genera already discovered in the Jurassic and Cretaceous of North America, and resembles *Ceratosaurus* in possessing a bony horn-core on the nose. As in the jaws of *Megalosaurus* previously known, the premaxilla of the new specimen bears four teeth; but these teeth are so different from those of the typical *M. bucklandi* of the same horizon that they prove the Minchinhampton fossil to belong to a distinct species.

2. "Problems of Ore-Deposition in the Lead and Zinc Veins of Great Britain." By Alexander Moncrieff Finlayson, M.Sc., F.G.S.

Chemical analyses show traces of lead and zinc in several of the rock-formations of Britain, but the ores of the veins are concluded to be derived, not from the country rock, but from deeper sources, probably in the first place by magmatic segregation. They were transported in the deeper zones by 'juvenile' waters, in which fluorine was an important constituent, while in the upper zones, especially in limestone districts, underground waters of meteoric origin have played a large part. The vein-solutions carried (1) alkaline sulphides, which held the sulphides of the metals in solution, and (2) alkaline and earthy carbonates. The presence of the latter is indicated by the alteration of the wall-rock, which shows a concentration of potash, lime, and carbon dioxide, and a leaching of soda, magnesia, oxides of iron, and silica. In limestones, however, the chief effects of solution on wall-rock were concentration of silica and magnesia.

The filling of fissures rather than direct replacement of rocks by ores has been the chief process, but the calcium of fluorspar has been very largely derived from the country rock. Further, much local metasomatism is seen, such as replacement of limestone by fluorspar, galena, blende, and quartz; and replacement of fluorspar by galena.

The order of deposition determined by microscopic examination of polished specimens of ores has been: chalcopyrite, fluorspar, blende, galena. The galena carries its silver generally in molecular or isomorphous combination, except in the case of rich ores, when native silver and argentite appear sometimes as threads along the cleavage-planes.

In the effect of the country rock on ore-deposition, the chief factors have been: (1) the physical character of the rock and the consequent nature of the fissure, (2) its porosity, and (3) its chemical composition. The process of deposition involves interchange of constituents between rock and solutions, even with the least soluble rocks.

Ore-deposition has persisted over a vertical range of 5000 to 6000 feet, of which over one-half has been shorn off by denudation. The effects of secondary processes have been exerted to depths of over 600 feet. The main points in the work are supported by field-observations, and by the results of microscopic and chemical research.

3. "The Vertebrate Fauna found in the Cave-Earth at Dog Holes, Warton Crag (Lancashire)." By John Wilfrid Jackson, F.G.S., Assistant Keeper in the Manchester Museum.

The remains described in this communication were obtained during the systematic investigation by the author of a cave on Warton Crag (West Lancashire) in 1909.

The cave, known as Dog Holes, is situated on the western side of Warton Crag, and opens on a sloping 'pavement' of limestone. It owes its origin to the erosion of a series of master-joints in the Carboniferous Limestone.

The present entrance to the cave is by a vertical drop from the general level of the 'pavement'. This entrance is undoubtedly of secondary origin, and is due to the falling-in of the weakened roof of one of the passages.

The specimens were derived from the cave-earth below the surface-soil in one of the chambers of the cave. They comprise a large series of small vertebrates, including Rodents, Insectivores, Amphibians, Birds, etc. Among the Rodents are some interesting forms, the chief of which are the Arctic and Norwegian Lemmings and the Northern Vole.

A large series of non-marine Mollusca was found along with these remains, one species being of particular interest, namely *Pyramidula ruderata*, only known in this country by its fossil remains in Pleistocene deposits.

The Pleistocene age of the remains is fully discussed, as well as their possible mode of origin through a former swallow-hole.

In many respects the cave and its contents bear a striking resemblance to the famous Ightham Fissures.

February 9, 1910.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

Dr. Douglas Mawson, B.Sc., B.E., Lecturer in Mineralogy in the University of Adelaide (South Australia), delivered a lecture entitled "With Sir Ernest Shackleton in the Antarctic", illustrated by lantern-slides.

The President proposed and Sir Archibald Geikie seconded a vote of thanks to the Lecturer, which was adopted with acclamation and suitably acknowledged.

II.—Mineralogical Society.

January 25.—Professor W. J. Lewis, F.R.S., President, in the Chair.

Dr. S. J. Shand: On a group of minerals formed by the combustion of pyritous shales in Midlothian. At the Emily Coal-pit, Arniston, as the result of the slow combustion of a heap of shaly refuse, which became spontaneously ignited, presumably owing to the evolution of heat caused by the atmospheric oxidation of pyrites, a number of uncommon mineral species have been formed, of which five have been recognized, viz. native sulphur, sal-ammoniac, tschermigite, mascagnite, and a possibly new species, aluminium sulphate.—Professor W. J. Lewis: A Crystal-holder for measuring large specimens. For this purpose a clamp of convenient form and with various adjustments has been designed and made by Mr. Pye.—Mr. T. Crook: Some observations on Pleochroism. The phenomena of pleochroism displayed by plates of coloured minerals when examined in ordinary light were treated in a general way for both parallel and convergent rays, and the factors upon which they depend were discussed.—Mr. L. J. Spencer: Notes on the Weight of the 'Cullinan' Diamond, and on the Value of the Carat-weight. Varying statements of the weight of the 'Cullinan' diamond, in its original, uncut form have been published, but from a comparison of the carat-weights against which it was weighed in 1905 it is concluded that the correct weight was 621·2 grams, or 3025¾ English carats of about 205·304 milligrams (as defined by the Standards Department of the Board of Trade in 1889). Other values are, however, given for the English carat and for the carat in other countries, and the average value has decreased on the whole in course of time. The carat-weight had its origin in the use as weights of seeds of *Ceratonia siliqua*, which weigh approximately a carat. The existing confusion would be obviated by the general adoption of the metric carat of 200 milligrams (one-fifth of a gram) recently recommended by the International Committee of Weights and Measures (*Nature*, 1908, vol. lxxii, p. 611).—Dr. G. T. Prior: On a Basalt from Rathjordan, Co. Limerick. Specimens of basalt from Rathjordan in the Allport Collection in the British Museum show in thin slices under the microscope round sections of isotropic material containing central and marginal inclusions, and thus resembling small leucites. The rock is very similar, mineralogically and chemically, to leucite-basalts from Bohemia, but contains only a small fractional percentage of potash. This fact, combined with observations of the refractive indices, leads to the conclusion that the isotropic material is mainly analcite and not leucite.—Dr. G. F. H. Smith and Dr. G. T. Prior: On a Fluo-arsenate from the Indian manganese deposits. A crystallographical and chemical examination made of the green arsenate from Kajlidongri, Jhábua State, mentioned in Mr. Fermor's monograph on the manganese-ore deposits of India (Rec. Geol. Surv. India, 1908), led to the following results:—Composition (Mg F) Ca AsO_4. Specific gravity, 3·768. Hardness, 3½. Colour, apple- to brownish-green. Monoclinic: a : b : c = 0·7485 : 1 : 0·8453 : $\beta =$ 120° 50′. Forms present (010), (110), (111), ($\bar{1}$31), (311), ($\bar{1}$12), ($\bar{1}$52). Good cleavage parallel to ($\bar{1}$01), and partings parallel to (110), ($\bar{1}$02), (331). Twin plane (100). Refractive indices, 1·640, 1·660, 1·666. Acute bisectrix nearly perpendicular to ($\bar{1}$01), and axial plane at right angles to the plane of symmetry, but no horizontal dispersion was noticed; 2 E = 105° approximately, with negative birefringence. The mineral is probably identical with tilasite, which was first described by Sjögren in 1905, from the manganese deposits of Långban, Sweden.—Mr. H. E. Clarke and Professor H. L. Bowman:

On the composition of a stone from the meteoric shower which fell at Dokáchi, Bengal, on October 22, 1903. The small crusted stone examined, weighing 17·8 grams, shows chondritic structure, and belongs to the class Ci of Tschermak. The chief constituent minerals are bronzite (37·9 per cent.), olivine (37·7 per cent.), nickel-iron (18·5 per cent.), troilite (4·1 per cent.).—Dr. G. F. H. Smith exhibited cut and rough specimens of synthetical sapphire, recently produced by Professor Verneuil, oxides of iron and titanium being the colouring agents.

CORRESPONDENCE.

THE USE OF THE TERM 'LATERITE'.

Sir,—I have read Mr. T. Crook's letter in the November number of this journal with interest, but fail to see that he has made it easier for everyone to agree with him in his use of the term 'laterite'. I do not say that the engineers of the Malay Peninsula are correct in their use of the term. They have not adhered to Buchanan's definition, but have extended it to cover masses of ironstone, which, even had they occurred in decomposition products of crystalline rocks, I am quite ready to admit would not have been included in the term 'laterite' by the originator. Similarly, I admit that in other countries the original definition has been abandoned, which is perhaps deplorable; but the question that occurred to me immediately on reading Mr. Crook's remarks was, what reason has he to consider himself in a better position as regards the original definition, which is conveniently given in his letter, than the rest?

The essential point in Buchanan's definition is the fact that laterite 'sets' when exposed to the atmosphere, and can be used as brick. Buchanan also says that it contains a very large quantity of iron in the form of red and yellow ochres. Now Mr. Crook says that Buchanan attached to the term 'laterite' a significance that is in strict agreement with modern usage, by which we must understand Mr. Crook's insistence on the importance of the free aluminium hydroxides. I can only take this to mean that in Mr. Crook's opinion the 'setting' of laterite is essentially due to the dehydration of the aluminium hydroxides, and if Mr. Crook can prove this proposition I am prepared to accept his definition as a somewhat obscure paraphrase of Buchanan's definition. At present I am unable to accept it as a paraphrase because, although a change from gibbsite to the hard but very brittle diaspore may to a small extent account for the hardening, it is but reasonable to suppose that in the case of Buchanan's indurated clays containing "a very large quantity of iron", the redistribution and partial dehydration of the ferric hydrate are the factors that make laterite commercially valuable (vide *Manual of the Geology of India*, p. 379, and Sir Thomas H. Holland's paper in the 1903 volume of the Geol. Mag., pp. 65, 66, and 69).

It is clear that the original definition of laterite has been generally ignored, perhaps because it appealed to an economic rather than a scientific point of view. But with that idea of economic value there was in the earlier writings always more than a suggestion of an abundance of iron, and those who apply the term now to distinctly ferruginous weathering products may be no nearer heresy than those who, following up the work of Max Bauer and Dr. Warth, insist on the presence of free aluminium hydroxides as the test of laterite. To me the term seems to be now of little value, and unless we can agree to apply it only to such materials as were described by Buchanan as possessing qualities that make them workable as a substitute for brick, I do not see why it should be retained. Mr. Crook tells me that I am not justified from a scientific standpoint in suggesting that highly aluminous laterite should be called bauxite. I follow Mr. Crook's argument, but since the following phrases occur in the papers by Sir Thomas Holland and Dr. Warth & F. J. Warth published in the Geological Magazine for 1903—"laterite . . . agrees in essential characters with bauxite"—"the essential chemical similarity between bauxite and laterite"—"laterites in situ which are bauxites"—"these bauxites in blocks and in powder"—"laterite is bauxite in various degrees of purity"—I feel that I am justified in advocating simplicity of diction as opposed to the redefining of a term the utility of which to geologists is doubtful.

The engineers, even if they have misapplied the term, are now the chief users of it, and weight of numbers will compensate such lack of scientific accuracy as exists in the eyes of the world at large. In local publications geologists placed like myself must make use of the term in order that local readers may know what is being discussed, and it was the objection in the Imperial Institute Bulletin to such a local use of the term that led me to write in the first instance, since I foresaw that the same might happen to me also. I believe that all geologists are agreed in aiming at simplicity of terminology. Can any geologist who has kept abreast of the literature use the term 'laterite' now without feeling an obligation to explain what he means by it? And is it not simpler to say directly what we mean without using a term whose original significance we have discarded?

J. B. Scrivenor.

Geological Department, Batu Gajah,
Federated Malay States.
January 19, 1910.

CAPE GEOLOGY.

Sir,—Will you allow me to point out that your reviewer has made a mistake in his otherwise very kind remarks on the book on Cape Geology written by Mr. Du Toit and myself? He says that "no references are given to any of the authorities quoted": a glance through the book will show that references to a considerable number of publications, in fact whenever such a course seemed desirable, are given in the foot-notes. In a book of this sort the omission of references would be a very serious fault, so the oversight on the part of the reviewer should be corrected.

Arthur W. Rogers.

Fraserburg, Cape Colony.
January 1, 1910.

JAW APPARATUS OF *DISCOIDEA*.

SIR,—In the course of examining and arranging some specimens of foreign *Echinoidea*, formerly in the Wright Collection and recently purchased for the British Museum, I have found an internal cast in flint of a *Discoidea*, which, from its size and general contour, seems referable to *D. cylindrica* (Lam.), although it is a remarkably depressed form. This cast exhibits clear impressions of the dental apparatus in a fragmentary condition, at least three of the teeth being represented among the other portions of the jaws. The characters of the jaws in this specimen accord, so far as they are visible, with those of the individual in the Manchester Museum (GEOL. MAG., 1909, pp. 148–52), which is almost equally depressed in outline. In view of the extreme rarity of the preservation of the dental apparatus in this genus, the existence of an example in the National Collection seems worth a published record. Unfortunately the precise locality and horizon are unknown. The specimen is registered E. 10166.

HERBERT L. HAWKINS.

UNIVERSITY COLLEGE, READING.
February 17, 1910.

OBITUARY.

THE REV. GEORGE FERRIS WHIDBORNE, M.A., F.G.S., ETC.

BORN 1846. DIED FEBRUARY 14, 1910.

IT is with deep regret we learn, from the *Morning Post*, February 17, of the death of our valued friend the Rev. G. F. Whidborne, M.A., at Hammerwood, East Grinstead, from an attack of pneumonia, in his sixty-fourth year. Mr. Whidborne formerly resided at Torquay, and in later years at Westbury-on-Trym, near Bristol. For the past twenty-five years he had devoted himself to figuring and describing "the Devonian fauna of the South of England", in the annual volumes of the Palæontographical Society, the first part of which monograph appeared in vol. xlii for 1888, and of which eleven fasciculi had been issued, the last part being published in 1907. Mr. Whidborne had served for many years on the Council of the Palæontographical Society, and has contributed papers to the Quarterly Journal of the Geological Society (in 1881 and 1883) and numerous papers to the GEOLOGICAL MAGAZINE (1889–1901). He was a most generous and kind-hearted man, an excellent palæontologist, and greatly esteemed by a very large circle of friends and fellow-workers.

MISCELLANEOUS.

MR. JAMES REEVE, F.G.S., AND THE NORWICH CASTLE MUSEUM.

The admirable Museum originally known as the "Norfolk and Norwich Museum" was initiated in February, 1825, by a small body of private gentlemen, naturalists and antiquaries connected with the city and county, and started with the modest annual subscription of 5*s*. each member. It is to the honour of these gentlemen and their friends and successors that the Norfolk and Norwich Museum continued (supported by voluntary contributions) for nearly seventy years, and had, at the time of its transfer to the Corporation, some fifteen years ago, in addition to its books and pictures, its antiquities, its recent and fossil collections, a fine series of British and foreign birds, and the finest collection of raptorial birds in the world, formed and presented to the Norfolk and Norwich Museum by the late John Henry Gurney, Esq.

In the Geological Collection are preserved the grand series of mammalian remains from the Forest Bed deposits of the Norfolk coast, formed by the late Mr. John Gunn, F.G.S., the Chalk and Crag collections of the late Mr. Samuel Woodward, besides those presented to the Museum in recent years by Mr. James Reeves, the present indefatigable curator.

In 1886 the Norwich Town Council, presided over by their then Mayor, Mr. John Gurney, proposed the conversion of the 'keep' and prison buildings adjoining the Norwich Castle into a series of museum galleries, with a view to the transfer of the collections now belonging to the Norfolk and Norwich Museum. A committee was formed to raise the necessary funds, to which Mr. John Gurney contributed the handsome sum of £5000.

More than £15,000 in addition were raised to complete the buildings, which were designed and carried out for the Corporation and the Museum Committee in 1887 and following years by Mr. E. Boardman, F.R.I.B.A., the city architect. Some years later Mr. James Reeve, F.G.S., the Curator, who had devoted forty-six years of his life to the Norfolk and Norwich Museum, undertook and carried out the transfer of the entire collections from the old building in St. Andrew's Street to the grand series of eight new spacious galleries and the 'keep' of the old feudal castle, and has since devoted sixteen years to the no less arduous task of arranging for exhibition the vast array of objects of art, pictures, antiquities, and relics; also of minerals, geological specimens, skeletons and skins of mammals, of birds and their eggs, of reptiles, of corals, insects, and mollusca, which now adorn these spacious and well-appointed galleries.

But life is short and art is long—what wonder, then, that Mr. James Reeve, who has served the Norfolk and Norwich Museum, and subsequently the Corporation of Norwich, for an almost unexampled period of sixty-two years, should be wishful to retire from his arduous duties and obtain some needful repose! Even now his beloved Museum is his first consideration, and he writes to the Town Clerk: "I have naturally no desire to entirely relinquish a connexion which has lasted for more than half a century." Whereupon the Castle Museum Committee (on January 5, 1910) resolved to place on record its high appreciation of the long and eminent services rendered by Mr. James Reeve, F.G.S., the Curator of the Castle Museum, etc., and to recommend that, in order to retain his valuable knowledge and experience, he be appointed Consulting Curator of the Museum, and that he be relieved from obligation to attend at the Castle during the usual hours that the Museum is open, but continue to give his advice and assistance to the Committee and its officers when required. It was further resolved that the salary of Mr. Frank Leney,[1] Assistant Curator, be raised to £200 per annum from January 1, 1910, and that the consideration of the appointment of a Curator to fill the position to be vacated by Mr. James Reeve be deferred until after June 24, 1910.

At a subsequent meeting on February 15 Dr. E. E. Blyth, the newly-constituted[2] Right Honourable the Lord Mayor, with the Aldermen and Councillors, adopted the report of the Museum Committee, and passed a cordial and well-deserved eulogium on Mr. James Reeve for his long and valuable services to the City of Norwich and its Museum. The Lord Mayor added that it was mainly due to Mr. Reeve that the Castle Museum contained more gems and less rubbish than any other of the Municipal Galleries in England. We heartily rejoice at the recognition given by the Corporation of Norwich to Mr. James Reeve for his valuable services, and trust that his life may long be spared to enjoy his comparative leisure and the well-earned appreciation of his fellow-citizens in Norwich.

In Memory of Dr. Slimon, of Lesmahagow, Lanarkshire.

So long ago as 1855, at the Meeting of the British Association, Mr. Robert Slimon exhibited in Glasgow a remarkable series of fossils from Lesmahagow. Among these was a series of Crustacean remains, with curious scale-like markings, exposed upon the surface of dark-coloured schist or flags, to which Mr. David Page called Sir Roderick Murchison's attention. Murchison at once recognized them as the remains of *Pterygotus*, and from the nature of the matrix concluded they belonged to the uppermost Silurian zone. At the close of the meeting, accompanied by Sir Andrew Ramsay and Dr. Slimon, Murchison visited the district, and, as the result of that visit, a very important addition was made to Scottish geology. Shortly afterwards Murchison read a paper to the Geological Society of London,[3] in which he stated that the dark fossiliferous shales exposed in the Logan Water pass conformably upwards into the Old Red Sandstone of that district. His paper was illustrated by a horizontal section showing the relationship that existed between the Upper Silurian strata of that region and the Old Red Sandstone. In his paper he also pointed out that Dr. Slimon's collection contained sculptured plates of Crustaceans exactly similar to those which had already been referred to *Pterygotus*. Associated with these he had found specimens of *Lingula cornea* and *Trochus helicites* shells, which were characteristic of the Upper Silurian rocks of Wales. Such, then, is a brief account of this remarkable discovery in Scottish geology made by Dr. Slimon sixty years ago.

The earliest Crustacean fossils, collected so zealously by Mr. Slimon,

[1] Formerly of the British Museum (Natural History), Cromwell Road, S.W.

[2] By command of His Majesty the King, February 2, 1910, that "the Chief Magistrate of the capital of the 'King's county' (Norfolk) should be raised to the rank of Lord Mayor" (*Eastern Daily Press*, February 16, 1910).

[3] See Q.J.G.S., 1856, vol. xii, pp. 15–19.

were described by the late J. W. Salter[1] and in a monograph by Professor Huxley & J. W. Salter[2]; the specimens figured are preserved in the Museum of Geology, Jermyn Street. The British Museum next received specimens from Mr. Slimon, and Dr. Henry Woodward entered upon their description;[3] a task which occupied him during intervals for more than fifteen years. Subsequently, in conjunction with Professor T. Rupert Jones, F.R.S., Dr. Henry Woodward prepared a monograph on the genus *Ceratiocaris* and other forms of Phyllocarida, many of which had been discovered by Mr. Slimon.[4]

Dr. Slimon, to whose energy and ability as a field-geologist and naturalist we owe so much, died at Lesmahagow, October 12, 1882, in his eightieth year.

In October last Dr. Slimon's sons and daughter presented the whole of their father's private collection, which he had added to up to his death, and which numbered over 5000 specimens, to the Kelvingrove Museum in Glasgow, where it will serve as a lasting memorial of Mr. Slimon's lifework. It may be interesting to learn that the shales containing these most coveted fossil-remains present their fissile edges vertically to the geologist, and are only to be met with in the beds and banks of the Nethan and Logan Waters and their tributary rivers. Here, standing knee-deep in clear cold water, Mr. Slimon and his sons spent many long days extracting their treasured fossils from their watery home in the river's rocky bed.

The story of Mr. Slimon's great discovery is interesting. He was bound for Logan Water House, situated almost at the source of the Logan Water, to perform a very common though urgent medical duty, when his eye was suddenly arrested by a dark object in the rocks beneath the waters of the stream. Proceeding to obtain possession of it, he became entirely oblivious to the existence of such a thing as a patient, and it was not till something like ten hours had elapsed that he was suddenly recalled to the mission upon which he was bent, which was accomplished on the following morning. From the time when he first discovered the fossils up till his death, a period of over fifty years, Dr. Slimon was continually accumulating the vast collection, the great bulk of which has now found its final resting-place in Kelvingrove Museum.[5] But many fine and beautiful examples (mostly figured types) are fortunately to be seen in the British Museum of Natural History, Cromwell Road, and in the Museum of Practical Geology, Jermyn Street, London; also in the Edinburgh Museum, where they have been described and figured by Professor Dr. Malcolm Laurie, F.R.S.E., of St. Mungo's College, Glasgow.

[1] Cf. Q.J.G.S., 1859, vol. xv, pp. 229–36, pl. x.

[2] T. H. Huxley & J. W. Salter, Mon. I, Mem. Geol. Survey, 1859, 8vo, pp. 105, with 16 folio plates.

[3] See *Intellectual Observer*, 1863, vol. iv, p. 229, and pl. i; Geol. Mag., 1864, Vol. I, p. 107, Pl. V; 1865, pp. 196 and 239, Pl. X; Brit. Assoc. Reports (Sect. C), 1865, Q.J.G.S., vol. xxi, p. 482, pls. xiii and xiv; Mon. Pal. Soc., *Merostomata*, 1865–78, pp. 1–263, pls. i–xxxvi.

[4] See Mon. Pal. Soc., *Palæozoic Phyllopoda*, 1887–99, pp. 211, pls. i–xxxi.

[5] Under the care of that indefatigable Scotch geologist and naturalist, Peter Macnair, F.R.S.E., F.G.S., the Curator of the Natural History Collections.

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APRIL, 1910.

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THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE V. VOL. VII.

No. IV.—APRIL, 1910.

ORIGINAL ARTICLES.

I.—Notes on new or imperfectly known Chalk Polyzoa.

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

(PLATE XIV.)

(*Continued from the February Number*, p. 77.)

MY next four species are linked together by their avicularia, which in each case have the side walls infolded over a long deep-set area.

Membranipora sagittaria, nov. Pl. XIV, Figs. 1–3.

Zoarium free or encrusting, always unilaminate.

Zoœcia elliptical; length of area ·42 to ·52 mm., with ·48 mm. a fair mean; breadth ·3 to ·35 mm.; the earlier specimens have practically common walls, the later ones show a progressive tendency to separation of the zoœcia and sometimes a tendency to develop a second margin which reduces the area ·29 to ·31 mm. in length and ·15 to ·2 mm. in breadth.

Oœcia very abundant but rather fragile, in the earlier specimens long and narrow, in the later ones showing a progressive tendency to broaden and fall back from the area.

Avicularia of two types. (*a*) Accessory: in the zone of *M. cor-anguinum* small oblong rings lying at the head of the zoœcium and occurring very regularly in pairs on either side of, and lying against, and slightly overlapping the oœcium, but nearly always failing to occur when a vicarious avicularium adjoins. In the specimen from the lower part of the *Actinocamax quadratus* zone, shown as Fig. 2, they are developing in two directions, in one becoming exsert and overlapping their surroundings, in the other sinking into the gradually deepening furrows between the zoœcia and becoming mere triangular indentations; the latter line of development alone persists in the specimen from the upper part of the *Act. quadratus* zone shown as Fig. 3. (*b*) Vicarious: oblong cells with a long narrow elliptical aperture; there is a strong transverse bow-shaped ridge at the head of the cell, immediately below which the bounding walls are very sharply bent inwards until they overhang the aperture and almost meet in the middle line; they curve slowly back again and disclose a fairly wide front wall at the foot of the cell; just below the point at which they cease to overhang the aperture a pair of stout denticles are developed from the margin of the aperture.

Found in the *M. cor-anguinum* zone at Gravesend, in the *Act. quadratus* zone in various parts of Hampshire, and in the *Belemnitella mucronata* zone in the Isle of Wight.

MEMBRANIPORA DOLIUM, nov. Pl. XIV, Figs. 4–6.

Zoarium free or encrusting, always unilaminate.

Zoœcia large; length of area ·35 to ·51 mm., with ·45 mm. as a fair mean; breadth ·28 to ·43 mm., with ·36 mm. as a fair mean; the giant form from the Cromer–Weybourne Chalk shown in Fig. 6 gives average length of area ·65 to ·7 mm. and breadth ·5 to ·55 mm.; the broad margins are quite distinct; the areas are more or less barrel-shaped, owing to the strong tendency at the head to a straight margin, and at the foot to a slight intrusion of the preceding oœcium.

Oœcia abundant, large, and globose.

Avicularia of two types. (*a*) Accessory: a pair of rings very uniformly present set against the areal margin at the upper corners. (*b*) Vicarious: elliptical cells with a wide elliptical aperture surrounded by a narrow front wall; at about one-third of the way down the cell the bounding walls are bent inwards until they slightly overhang the aperture; they continue for another one-third of the cell to overhang the aperture in a slowly increasing degree, and are then cut back to the edge of the aperture at a right angle, and for the rest of the length of the cell coincide with the margin of the aperture.

Found in the *Act. quadratus* zone at various points in Hampshire, and with *B. mucronata* at Bramford in Suffolk, and in the Cromer–Weybourne Chalk, but not yet at Trimingham. It agrees very closely with *M. lyra*, as figured by Hagenow,[1] except that the latter has not vicarious avicularia according to either figure or description, and it is not likely that Hagenow would have overlooked them if they did occur.

MEMBRANIPORA ANGUIFORMIS, nov. Pl. XIV, Figs. 7 and 8.

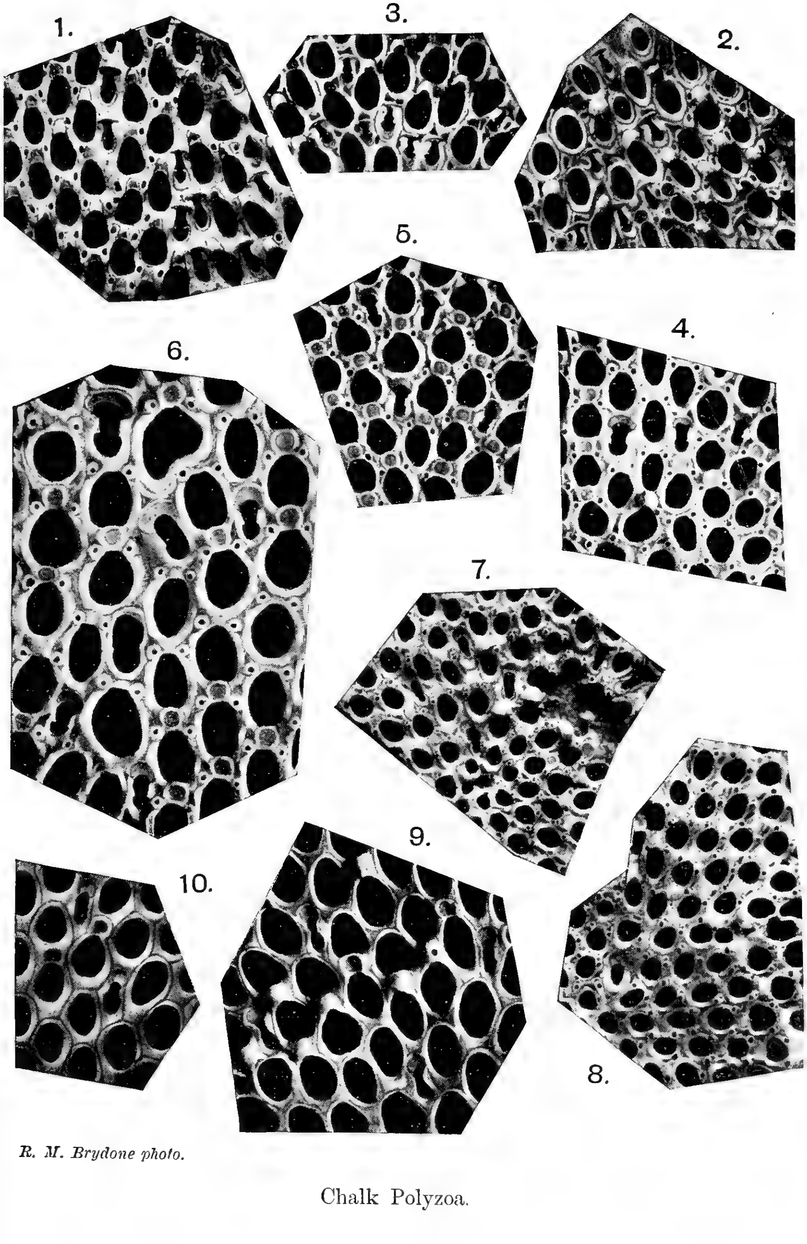
Zoarium unilaminate, always encrusting.

Zoœcia small, length of area ·27 to ·32 mm., breadth ·23 to ·26 mm., subcircular, with very distinct margins, and often separated by deep fissures.

Oœcia very abundant, but very fragile; the specimens shown by Fig. 7 are the only ones I have seen, and unfortunately three out of the four have become defective and the fourth cracked since that photograph was taken; they are very wide, but too short to reach the area, with straight free edges, their general shape being much that of a beehive; the traces they leave when broken away are very indistinct.

Avicularia of two types. (*a*) Accessory: a pair of perforated tubercles very constant in occurrence, set on the margins at the upper corners of the zoœcia, and having nearly always in mature zoœcia a low semicircular extension upwards, with a shallow pore at the change of level; they then combine with the zoœcial margin to give a strong suggestion of the upper half of a snake. (*b*) Vicarious: largish elliptical cells, with a long narrow aperture tapering slightly from head to foot, and constricted near the foot by two small paired

[1] Loc. cit., p. 98, pl. xi, fig. 2.



R. M. Brydone photo.

Chalk Polyzoa.

denticles, and surrounded by a narrow front wall which is deep-set at the head of the cell, and rises steadily towards the foot ; in the centre of the cell the bounding walls are bent rather sharply inwards to the edge of the aperture and back again ; these avicularia have a strong general resemblance to those of *M. invigilata*, but it will be observed that the denticles in *M. anguiformis* and *M. sagittaria*, being processes from the margin of the aperture, are not analogous to the denticles of *M. invigilata*, which are processes from the bounding wall.

Found only at Trimingham.

MEMBRANIPORA LANGI,[1] nov. Pl. XIV, Figs. 9 and 10.

Zoarium unilaminate, always encrusting.

Zoœcia often large, but very variable ; length of area ·43 to ·7 mm., with ·65 mm. as a fair mean in good specimens ; breadth ·32 to ·5 mm., with ·45 mm. as a similar mean ; boundaries clearly marked owing to differences of level between adjoining zoœcia but not by any furrow.

Oœcia long and rather straight-sided, often projecting slightly over the area of the succeeding zoœcium, and generally rising from a slight protrusion of the margin of the aperture ; in one zoœcium in Fig. 9 the protrusion has been formed, but no oœcium has developed from it.

Avicularia of one type (vicarious) only, rather low-lying, and forming the initial cells of new rows of zoœcia ; elliptical, with wide elliptical apertures surrounded by a fairly wide front wall at the head of the cell and by a narrower one at the foot, but overhung considerably in the middle by the very symmetrically inbent edges of the bounding walls, which present the outline of an hour-glass.

Found abundantly at Trimingham, occasionally in the Cromer–Weybourne Chalk, and once in the *Act. quadratus* Chalk of Hampshire.[2]

EXPLANATION OF PLATE XIV.

(All figures × 11 diam.)

FIG. 1. *Membranipora sagittaria*, zone of *M. cor-anguinum*, Gravesend.
,, 2. Ditto, zone of *Act. quadratus* (lower part), Hants.
,, 3. Ditto, zone of *Act. quadratus* (upper part), Hants.
,, 4. *M. dolium*, zone of *Act. quadratus* (upper part), Hants.
,, 5. Ditto, zone of *B. mucronata* (?), Bramford, Suffolk.
,, 6. Ditto, Cromer–Weybourne Chalk.
,, 7. *M. anguiformis*, Trimingham.
,, 8. Ditto, Trimingham (another specimen).
,, 9. *M. Langi*, exceptionally preserved, Trimingham.
,, 10. Ditto, in ordinary preservation, Trimingham.

II. — ON A NEW SPECIES OF FOSSIL COCKROACH, *ARCHIMYLACRIS* (*ETOBLATTINA*) *WOODWARDI*, FROM THE SOUTH WALES COAL-FIELD.

By HERBERT BOLTON, F.R.S.E., F.G.S., of the Bristol Museum of Natural History.

(PLATE XV.)

THE Orthopteron wing which forms the subject of the present paper was obtained by Mr. David Davies from a dark-blue shale, about 10 feet in thickness, overlying the No. 2 Rhondda coal-seam in

[1] Dedicated to W. D. Lang, Esq., of the British Museum (Natural History).
[2] *Erratum :* p. 76, l. 29, *for* construction *read* constriction.

Clydach Vale (see Plate XV). The shale decreases to the east, dying out wholly 2 miles beyond the colliery, giving place to sandstone. I am indebted to Mr. Davies for the opportunity of describing the specimen.

The wing or tegmina lies upon a very small piece of black shale and shows the upper surface, which is gently convex along the middle, somewhat hollowed over the mediastinal area, and more strongly curved along the inner margin and over the anal area. The basal portions of all the veins, and the whole of the internomedian and anal veins are well elevated above the general surface, the rest lying, as do all the smaller branches, below the general level. The 'cross-veins' of Scudder are remarkably well preserved over the whole wing surface, forming a multitudinous series of fine close-set parallel ridges, which give a ladder-like appearance to the areas lying between the veins. The general impression is that of a finely wrinkled integument, which it really is, for where the chief veins or their branches are sunken, the 'cross-veins' pass clean across the vein without any break, or any visible connexion. This is especially noticeable in the mediastinal area, where the wrinkles can be traced over several of the tertiary branches of the vein in succession. All the wing anterior to the internomedian area, and with the exception already noted, i.e. the base of the principal veins, is distinguished by the veins lying in shallow troughs, between which the wing-structure rises in a well-rounded surface. The internomedian and anal areas, on the other hand, form an inner and smaller division of the wing in which all the veins are in high relief, the wrinkled surface lying in flattened hollows between.

The wing appears to be complete, but is encroached upon by the shale in two small places on the outer margin. Considering the wing as a whole, it may be described as stout and robust, much shorter for its width than is seen in most species of *Etoblattina*, and possessing a regularly convex anterior margin which passes insensibly into the outer border; the latter is almost semicircular in outline, whilst the inner border is so feebly concave as to at first appear perfectly straight. At the base of the wing the full course of the veins cannot be traced to their point of attachment.

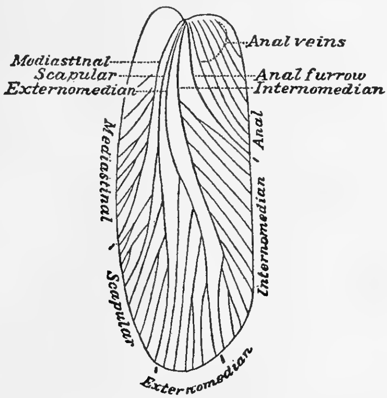
The mediastinal vein curves forward for two-thirds of its length, then backwards, but not so sharply as the margin of the wing, which it therefore continues to approach. Finally it bends outward and runs to the margin, reaching the latter a little beyond the middle. The whole course of the vein is somewhat sigmoidal, and not so straight, for example, as shown by Scudder in *E. venusta.*[1]

Sixteen secondary veins at least spring from the mediastinal, four of which do not bifurcate. In the basal third of the area the presence of secondary veins cannot be distinguished. All the secondary veins approach the margin obliquely, with the exception of the last, which curves forward to meet it. The scapular vein forks at about the first quarter of its length into two unequal secondary branches. The anterior branch, which is the smallest, runs somewhat parallel to the

[1] Scudder, "Palæozoic Cockroaches": Boston Soc. Nat. Hist., vol. iii, pl. vi, fig. 12.

mediastinal vein, breaking up into fine tertiary veins, the first two of which again fork before reaching the margin. The median branch of the scapular divides into two equal tertiaries, the anterior forking twice before reaching the margin, and the hinder forking but once.

The scapular area occupies a little less than the outer half of the anterior margin of the wing, and almost exactly half of the external margin. Notwithstanding a general correspondence of the scapular vein with that of *E. venusta*, it occupies more of the anterior margin, owing to the forward curve of the anterior secondary vein, a curve which is continued in the tertiary branches, causing them to reach the margin a little beyond the middle of the latter's length.



Outline figure of one of the tegmina of *Etoblattina mazona*, from the Carboniferous beds of Illinois, with the nomenclature of the veins as used by Heer and followed by Scudder (see Bulletin U.S. Geological Survey, No. 124, 1895, "Revision of the American Fossil Cockroaches, etc.," p. 37, fig. 3).

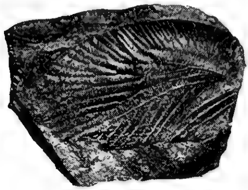
The *externomedian* vein follows a sub-parallel course to the hinder secondary of the scapular, and remains undivided until it reaches the secondary forking of the latter. In this respect, the specimen again differs from *E. venusta*, where the forking occurs at a lower level. An examination of Scudder's drawing shows that the primary forking of the externomedian, and the secondary forking of the scapular, lie in an oblique line directed forwards and outwards, whilst in the present case the same points of division lie upon a straight line bisecting the wing. The externomedian in the present specimen shows no internomedian branch in its lower third such as is indicated by Scudder. Beyond the first fork the hinder branch divides twice, so that the externomedian divides up into four branches, all of which reach the margin without further subdivision. The externomedian area is very small, and subtends not more than one-third of the tip of the wing. The *internomedian* vein follows a course parallel to the main axis of the externomedian, and after curving backwards a little in the first quarter of its length, passes straight outward to the hinder edge of the wing tip, giving off to the inner margin nine simple straight and unforked branches. The marginal area occupied by this vein and its branches includes the outer two-thirds of the inner margin, and a small portion of the outer or tip of the wing. A slight fold separates the anal veins from the lowest branch of the internomedian, and divides off a small triangular lobe from the rest of the wing. The anal lobe thus formed is crossed by four anal veins which run parallel, and in the case of the basal two at least fork before they reach the margin. In the almost straight course which the anal veins pursue to the inner margin they are in marked contrast to those of *E. venusta*, whilst the anal area is also much less.

Specific Relationships.—A comparison with the tabulated specific characters of all known European and American *Etoblattina*, shows that this specimen presents well-marked differences. From *E. manitoides*[1] it differs in the greater length of the mediastinal vein and its area, in the presence of four anal veins, and in the more simple unbranched character of the internomedian. The differences of shape, size, and character of the veins when contrasted with *E. Johnsoni*, Woodward (Geol. Mag., New Ser., 1887, Dec. III, Vol. IV, p. 53, Pl. II, Figs. 1*a–b*), are still greater. It will be sufficient to note that the mediastinal area is almost one-half less than in *E. Johnsoni*. *E. Deanensis*, Scd., shows a somewhat superficial resemblance, but in that species the wing is narrower, and possesses a somewhat pointed tip in place of the well-rounded margin shown in our specimen. The general courses of the mediastinal and scapular veins are much less curved; and the latter is regularly forked, which is not the case in this species. The specimen, on the other hand, agrees perfectly with Scudder's description of *E. propria* (op. cit.) in that the tegmina is less than twice as long as broad; the mediastinal area reaching nearly to the middle of the distal half of the tegmina; and the externomedian first forking beyond the middle of the wing.

An examination, however, of Kliver's figure (*Palæontographica*, xxix, pl. v, taf. xxxv, fig. 3) shows that the mediastinal area is longer in *E. propria*, and that the veins in the latter pursue a much straighter course. The chief difference, however, lies in the character of the scapular vein. In *E. propria* the scapular vein gives off the externomedian, about 8 mm., above the base of the wing, whilst it is questionable whether these were ever united at all in the Welsh specimen. Unfortunately, the specimen is not sufficiently well preserved at the base to establish the point. Even had the two veins a common origin, the externomedian vein must have been given off from the scapular at the very base of the wing. It is, however, in the shorter mediastinal area, the forward curving of all the ultimate branches of the mediastinal and scapular veins, the more regular convexity of the anterior border, and the evident concave posterior or inner margin, that the chief differences consist, and constitute what may be regarded as specific identity. Further, Kliver's drawing shows no trace of 'cross-veins', which are so strongly marked upon the tegmina of our specimen, the interstices between the veins being filled instead with a close reticulation.

Handlirsch ("Revision of American Palæozoic Insects," Proc.

[1] Scudder, Mem. Boston Soc. Nat. Hist. Soc., 1879, vol. iii, pl. i, No. 3.



1/1

1*a*.

2/1

1*b*.

Photo by J. W. Tutcher.

Archimylacris (*Etoblattina*) *Woodwardi*, Bolton. South Wales Coal-field.

United States Nat. Mus., 1906, vol. xxix, pp. 661–820), who received the entire collection of Scudder's types in 1902, has since produced a monograph materially altering the relationships of many of the forms previously described, established a number of new genera, and revised previously existing ones. In the light of Handlirsch's conclusions, our specimen falls into the genus *Archimylacris* of Scudder, the type of which is *Archimylacris acadica*, Scd., with *Archimylacris* (*Etoblattina*) *venusta* as a nearly related species. I have much pleasure in naming the species *A. Woodwardi*, after Dr. Henry Woodward, to whom more than any other in this country palæontologists are indebted for their present knowledge of Palæozoic insects.

EXPLANATION OF PLATE XV.

FIG. 1*a*. Wing or tegmina of *Archimylacris* (*Etoblattina*) *Woodwardi*, Bolton. Nat. size; length 18 mm., width 10 mm. Photographed from the original specimen by Mr. J. W. Tutcher.

,, 1*b*. The same wing enlarged rather more than twice natural size.

The specimen was obtained by Mr. David Davies from a dark-blue shale (about 10 feet in thickness) overlying the No. 2 Rhondda Coal-seam in Clydach Vale.

III.—SOME NEW SPECIES OF THE CIRRIPEDE GENUS *SCALPELLUM* FROM BRITISH CRETACEOUS ROCKS.

By THOMAS H. WITHERS.

SINCE the publication of Charles Darwin's memorable monograph on the Fossil Lepadidæ (Palæontographical Society, 1851) little has been written on the British Cretaceous Cirripedes. Among the thirteen species of *Scalpellum* which Darwin figured and described, ten are British, and, so far as I am aware, only one, *Scalpellum attenuatum*,[1] has since been added to their number. Several species have, however, subsequently been described from Foreign Cretaceous Rocks.

During an examination of the collection of English Cretaceous Cirripedes in the British Museum (Natural History), I noticed several specimens which cannot be referred to any described species. They all belong to the genus *Scalpellum*, and by permission of the Keeper of the Geological Department, descriptions and figures are now given of them.

The work of comparison has been rendered easier by the identification, in the course of it, of several of the type-specimens figured and described by Darwin (1851). Some of these are referred to in the following pages.

Although I have followed Darwin and later authors in regarding certain characters as of specific value, I do not ignore the possibility that the forms here described as distinct species may eventually prove to be only stages or mutations in their development, and may perhaps connect forms already known. But not until all the existing material shall have been discriminated and recorded, and additional specimens are available from several horizons, will it be possible to apply

[1] H. Woodward, "Cirripedes from the Trimmingham Chalk and other localities in Norfolk": GEOL. MAG., 1906, Dec. V, Vol. III, p. 352, Text-fig. 37.

Darwin's theory of evolution to the fossils which his study has rendered classical.

1. Scalpellum accumulatum, sp. nov. Figs. 1–4.

Diagnosis.—Carina narrow, moderately tapering, considerably bowed inwards, with inner margin much curved, not divided into parietes and intraparietes; apex pointed; basal margin rounded. Tectum very gently convex, almost flat, with obscure central ridge, marked off from the parietes by a well-developed ridge. Parietes narrow, less than half the width of the tectum, inflected, gently concave. Ornament: fine obtusely-angled V-shaped growth-lines continued over the parietes; near the basal margin are five ridges, similar in shape to the growth-lines, but irregularly spaced, strongly marked, and sharper on the parietes.

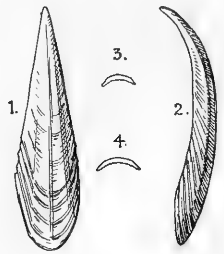


Fig. 1. *Scalpellum accumulatum*, T. H. Withers, sp. nov. External view of carina, × 2 nat. size. Aptian, upper part of Lower Greensand (Folkestone Beds): Folkestone, Kent. (B.M., I. 12,928.)
,, 2. Id. Side view, × 2 nat. size.
,, 3. Id. Transverse section at one-third from apex, × 2 nat. size.
,, 4. Id. Transverse section at one-third from base, × 2 nat. size.

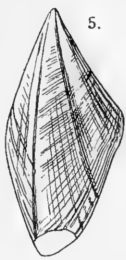
Holotype.—A carina (B.M., I. 12,928) collected by Mr. F. H. Butler. The specimen, of which the basal margin is slightly broken, is in a matrix of very coarse-grained greensand. Extreme length 17 mm., breadth 4 mm.

Horizon and Locality.—Aptian, upper part of Lower Greensand (Folkestone Beds): Folkestone, Kent.

Comparison with other Species.—*Scalpellum simplex*, Darwin (1851, p. 39, pl. i, fig. 9), of which only a single carina is known, is the only species of the genus previously known from the Lower Greensand of the British Isles. It differs from *S. accumulatum* in having the parietes more inflected, set inwards, and not extending to the basal margin. Also in the much more convex transverse section of the carina, and the smooth surface. *S. accumulatum* may also be compared with *S. arcuatum*, Darwin (1851, p. 40, pl. i, fig. 7), from the Gault, and *S. trilineatum*, Darwin (1851, p. 38, pl. i, fig. 5), from the Grey Chalk, with both of which it agrees in the absence of a division into parietes and intraparietes. From *S. arcuatum* it is readily distinguished by the absence of the longitudinal ridges, and from *S. trilineatum* by the absence of the well-marked rounded central ridge, and the presence of the prominent V-shaped ridges near the basal margin. The type of *S. trilineatum* (B.M., 38,461) was collected by W. Griffiths in the Grey Chalk (Cenomanian) of Dover. *S. accumulatum* also disagrees with *S. angustatum* (H. B. Geinitz)[1] from the Plänerkalk of Strehlen, Saxony, and *S. quadricarinatum* (A. Reuss)[2] from the Plänerkalk of Bohemia, in the absence of intraparietes. *S. quadricarinatum* further differs in the abrupt truncation of its basal margin.

2. Scalpellum comptum, sp. nov. Fig. 5.

Diagnosis.—General outline of tergum almost rhomboidal, ornamented with fine raised longitudinal ridges, some being finer than others. Apex pointed, but not sharply; basal angle probably rounded. Carinal margin forming an obtuse angle. Scutal margin sinuous, longer than the occludent margin, which is almost straight. A delicate furrow divides the valve unequally from the apex to the basal margin, the occludent portion being in its widest part about three times the width of the carinal portion. Carinal portion of valve ornamented with several fine raised longitudinal ridges, one of which is situated immediately at the side of the furrow, making the furrow more conspicuous. Occludent portion almost equally divided by a prominent raised ridge, somewhat coarser than the others, extending from the



5.

Fig. 5. *Scalpellum comptum*, T. H. Withers, sp. nov. External view of left tergum, × 4 nat. size. Aptian, Lower Greensand: Sevenoaks, Kent. (B.M., I. 13,403.)

apex to the scutal margin. Between this ridge and the furrow the valve is ornamented with longitudinal ridges, which are finer and less elevated than those on the rest of the valve. The occludent margin has a raised border ornamented with several longitudinal ridges, similar in size to those on the carinal portion of the valve, followed by a wide groove, almost smooth, extending from the apex to the scutal margin, which is immediately bounded by the single longitudinal ridge. The growth-lines are more conspicuous on the occludent portion, where they are sinuous. This sinuosity is more marked between the single longitudinal ridge and the occludent margin.

[1] *Die Versteinerungen von Kieslingswalda*, etc., Dresden and Leipzig, 1843, p. 7, pl. iv, fig. 10.

[2] *Die Versteinerungen der Böhmischen Kreideformation*, Stuttgart, 1846, p. 105, pl. xlii, fig. 18.

Holotype.—Left tergum (B.M., I. 13,403), Caleb Evans Collection. Length of valve about 8 mm., breadth 4 mm., length of occludent margin about 5 mm., length of scutal margin 4 mm.

Horizon and Locality.—Aptian, Lower Greensand: Sevenoaks, Kent.

Another specimen, a right tergum (B.M., 13,404) from the same collection, locality, and horizon, undoubtedly belongs to this species.

Both terga have their basal angles broken, but judging from the adjoining outline of the margins there is little doubt that they were rounded. The left tergum is taken as the holotype, as it is the most perfect.

Comparison with other Species.—Under the name *Pollicipes radiatus*, J. de C. Sowerby (1836),[1] figured two valves of a Cirripede, which appear to be of different species. The only description given is: "Valves wedge-shaped, flat, marked with sharp, elevated rays, diverging from their apices." Darwin in his monograph (1851, p. 40) says of *Scalpellum arcuatum*: "This species appears to come nearest to *Pollicipes radiatus* of J. de C. Sowerby . . . but besides that that species comes from the Lower Greensand, the lower angle is much more pointed; the upper figure of the two appears to be something wholly different." Further, Darwin (1851, p. 80) says: "The *P. radiatus* of the same author (J. de C. Sowerby) of the Lower Greensand (pl. xi, fig. 6) is unknown to me; the tergum figured is like that of *S. arcuatum*; the upper figure, if a scutum, is very remarkable." As these two valves figured by J. de C. Sowerby apparently belong to different species, it seems advisable to fix the holotype, and I therefore select the upper figure as the type of *Pollicipes radiatus*. It may be that Sowerby's lower figure represents a valve of *S. comptum*, but since the specimen cannot now be traced, and the figure and description are quite insufficient for exact determination, it is advisable to establish a new species for the specimens mentioned above, and to place in it provisionally the original of Sowerby's lower figure.

S. comptum may be compared with the Albian *S. arcuatum*, Darwin (1851, p. 40, pl. i, fig. 7), from the Gault, and *S. fossula*, Darwin (1851, p. 24, pl. i, fig. 4), from the Senonian (*Bel. mucronata*-zone) of Norwich. Both agree with it in having a delicate furrow extending from the apex to the basal angle; *S. fossula* further agrees in having a slight longitudinal ridge dividing the occludent portion into two parts. This ridge, however, is not raised as in *S. comptum*. In *S. fossula* the surface is not ornamented with raised longitudinal ridges, but is almost smooth; the carinal portion of the valve is proportionately much narrower, the apex and the basal angle are much more pointed, and the scutal margin is not sinuous. *S. arcuatum* differs by the absence of the raised longitudinal ridge extending from the apex to the scutal margin, and by the lines of growth being much more sinuous on the occludent portion. The general outline is more

[1] Descriptive notes respecting the shells figured in pls. xi to xxiii, Appendix A, to W. H. Fitton, "Observations on some of the Strata between the Chalk and the Oxford Oolite in the South-East of England": Trans. Geol. Soc., ser. II, vol. iv, pl. xi, fig. 6.

oval, and the raised longitudinal ridges which occur nearly regularly over the entire valve give it a far different appearance.

3. Scalpellum cyphum, sp. nov. Figs. 6–9.

Diagnosis.—Carina narrow, moderately bowed inwards, with inner margin slightly curved, widening gradually from the apex, which is sharply pointed, divided into parietes and intraparietes; basal margin angular (about 75°). Tectum strongly arched transversely. Parietes narrow, steeply inclined from the tectum, slightly concave, about half the width of the tectum, widening gradually to the basal margin. Tectum and parietes ornamented with a number of coarse, rounded, longitudinal ridges, readily seen with the naked eye. One stronger ridge runs down the middle of the tectum, and one on each side divides the tectum from the parietes. The interspaces between the ridges are about three times the width of the ridges. Intraparietes separated from the parietes by a strong rounded ridge, measuring in their widest part slightly more than the rest of the valve at that part, widening rapidly from the apex and then narrowing rapidly until a little more than half-way down the valve, when they merge into the sides of the parietes, at a short distance from their basal margins. Surface of tectum and parietes covered with well-marked V-shaped growth-lines.

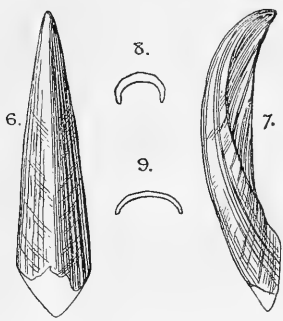


Fig. 6. *Scalpellum cyphum*, T. H. Withers, sp. nov. External view of carina, × 2 nat. size. Cenomanian, Grey Chalk: near Dover, Kent. (B.M., I. 13,405.)
,, 7. Id. Side view, × 2 nat. size.
,, 8. Id. Transverse section at one-third from apex, × 2 nat. size.
,, 9. Id. Transverse section at one-third from base, × 2 nat. size.

Holotype.—A carina (B.M., I. 13,405), J. Starkie Gardner Collection. Extreme length about 22 mm., greatest breadth 5 mm. The basal angle of the specimen is broken, but judging from one side of the margin it was probably angular.

Horizon and Locality.—Cenomanian, Grey Chalk: near Dover.

There is in the British Museum (Natural History), (B.M., I. 13,406), from the same horizon, locality, and collection, a smaller carina, which probably belongs to this species. It agrees in most of its characters with the preceding description, but the central longitudinal ridge is more pronounced, and some of the remaining ridges on the tectum and parietes are more irregularly placed and a little less coarse.

Comparison with other Species.—The Albian *Scalpellum arcuatum*, Darwin (1851, p. 40, pl. i, fig. 7), a common Gault species, also has longitudinal ridges, which, however, are finer and confined to the tectum. *S. cyphum* is at once distinguished from that species by its greater transverse convexity and by the presence of intraparietes. It agrees in some of its characters with *S. aduncatum*, sp. nov. (see *infra*), but the far more numerous and much coarser longitudinal ridges give it an entirely different appearance. It is also more convex transversely, has less obliquely inclined parietes, more pointed apex, curved inner margin, and the ridge that separates the parietes from the intraparietes is much more strongly rounded and conspicuous.

4. Scalpellum aduncatum, sp. nov. Figs. 10–13.

Diagnosis.—Carina narrow, moderately bowed inwards, inner margin nearly straight, widening gradually from the apex, divided into parietes and intraparietes, apex very sharply pointed and a small portion of it probably projected freely, basal margin angular (about 75°). Tectum moderately arched transversely, ornamented with about ten sharply raised longitudinal ridges, all of which can be seen with the naked eye; one strong ridge runs down the middle, followed on each

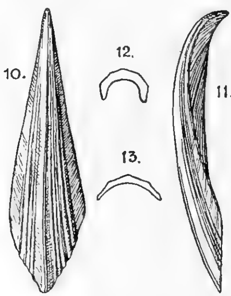


Fig. 10. *Scalpellum aduncatum*, T. H. Withers, sp. nov. External view of carina, × 2 nat. size. Cenomanian, upper part of *Holaster subglobosus*-zone: Oxted Lime Works, Oxted, Surrey. (B.M., I. 7235.)
,, 11. Id. Side view, × 2 nat. size.
,, 12. Id. Transverse section at one-third from apex, × 2 nat. size.
,, 13. Id. Transverse section at one-third from base, × 2 nat. size.

side by two or three finer ridges, which are bounded on either side by a pair of stronger ridges, close together, dividing the tectum from the parietes. Parietes narrow, obliquely inclined from the tectum, concave, about half the width of the tectum, widening slowly to the basal margin, and ornamented with extremely fine longitudinal striæ, which can only be seen with a lens. Intraparietes set a little inwards, separated from the parietes by a well-marked ridge, measuring in their widest part slightly more than the rest of the valve at that point, widening rapidly from the apex, and then narrowing rapidly until they reach little more than half the length of the valve, where they merge into the sides of the parietes, some distance from their basal margins. Surface of tectum and parietes ornamented with very fine V-shaped lines of growth.

Holotype.—A carina (B.M., I. 7235), collected by C. P. Chatwin and T. H. Withers. Extreme length 19 mm., greatest breadth 4·5 mm.

Horizon and Locality.—Cenomanian, upper part of zone of *Holaster subglobosus*: Oxted Lime Works, Oxted,[1] Surrey.

Comparison with other Species.—This species is not unlike *Scalpellum lineatum*, Darwin (1851, p. 35, pl. ii, fig. 12), but in that species the sides of the tectum are steeply inclined towards each other, the parietes and intraparietes are only separated by a very slight ridge, the disposition of the longitudinal ridges is different, and the interspaces are ornamented with very fine hair-like lines. It may also be compared with *S. angustum* (Dixon), (1850, Geol. Sussex, pl. xxviii, fig. 9), and *S. hastatum*, Darwin (1851, p. 37, pl. ii, fig. 13), both of which were founded on single carinæ. It agrees with *S. angustum* in that the intraparietes only reach about half the length of the valve; but disagrees with it in that their bases are not abruptly truncated, but merge into the sides of the parietes. Further, the main ornament is formed, not by the V-shaped lines of growth, but by the longitudinal ridges. From *S. hastatum* it differs in that the valve is much less recurved, has shorter and wider intraparietes, and well-marked longitudinal ridges. The holotype of *S. hastatum* (B.M., 38,462) was collected by W. Griffiths in the Grey Chalk (Cenomanian) of Dover. Unfortunately, since Darwin figured it the apex has been broken off and lost.

5. Scalpellum lineatum, Darwin.

1851. C. Darwin, Pal. Soc. Monogr. Foss. Lepadidæ, p. 35, pl. ii, figs. 11, 12.
1877. H. Woodward, B.M. Cat. Foss. Crustacea, p. 142.

Darwin had for the description of this species, two carinæ, a scutum, and a tergum, but he assigned the two latter valves to the species only with doubt. Taking this into consideration, and since it is best that the type should be fixed, I here select the carina figured by Darwin (op. cit., pl. ii, fig. 12) as the holotype of *S. lineatum*.

One of the carinæ was in the collection of J. Sowerby, and the remaining carina and the scutum in the collection of J. Morris. All three valves came from the Lower Chalk of Sussex. Unfortunately I have been unable to discover what has become of them.

The tergum (B.M., I. 13,402) came from the Lower Chalk of Maidstone, Kent, and was formerly in the Bowerbank Collection.

6. Scalpellum dissimile, sp. nov. Fig. 14.

Diagnosis.—General outline of tergum rhomboidal; apex sharply pointed; basal angle pointed. Scutal margin straight, shorter than the occludent margin, about half the length of the valve. Carinal margin divided into two lines forming an obtuse angle, the upper portion shorter than the lower, and about the length of the scutal margin, the lower portion being about the length of the occludent

[1] Exposure noticed, G. E. Dibley, "Zonal Features of the Chalk Pits in the Rochester, Gravesend, and Croydon Areas": Proc. Geol. Assoc., 1900, vol. xvi, p. 492.

margin. Surface of valve ornamented with fine, almost regular, longitudinal ridges, rather close together, the interspaces about the width of the ridges. Running transversely to these, at regular intervals, are about sixteen folds or ridges, which probably correspond to the growth-lines. A prominent ridge extends in a straight line from the apex to the basal angle, dividing the valve into two unequal portions, the occludent portion being the broadest. This ridge on reaching about half the length of the valve bifurcates, but with a very narrow interspace; the ridge is very little thicker than those on the occludent portion, but it is prominent because the carinal portion of the valve lies on a lower plane than the rest of the valve, and the ridge on the carinal side has an almost perpendicular face. The longitudinal ridges, of which there are about eleven on the carinal portion, are flattened, the first two or three on the inside being bifurcated at their bases, and the interspaces very narrow. Those on the occludent portion, numbering thirteen, are sharply rounded, and more pronounced, the interspaces about the width of the ridges. From the apex to the scutal margin runs a faint groove, from which the occludent margin rises up.

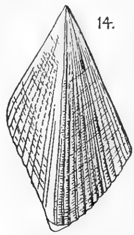


Fig. 14. *Scalpellum dissimile*, T. H. Withers, sp. nov. External view of left tergum, × 4 nat. size. Turonian, *Terebratulina*-zone; Gatehampton Farm, east of Goring-on-Thames, Oxon. (B.M., I. 8398.)

Holotype.—A left tergum (B.M., I. 8398), collected by C. P. Chatwin & T. H. Withers. The specimen has its basal angle slightly broken. Length of valve 7·5 mm., breadth 4 mm., length of occludent margin 5 mm., length of scutal margin 3·5 mm.

Horizon and Locality.—Turonian, upper part of *Terebratulina*-zone: Gatehampton Farm,[1] east of Goring-on-Thames, Oxon.

Comparison with other Species.—This tergum apparently agrees more closely with *S. attenuatum*, H. Woodward (1906, Geol. Mag., Dec. V, Vol. III, p. 352, Text-fig. 37) than any other species. The holotype of *S. attenuatum* is a tergum from the Senonian (*Bel. mucronata*-zone) of Harford Bridges Pit, near Norwich, and is in the collection of Dr. A. W. Rowe, who has kindly lent it to me for comparison. It is about three times the size of the holotype of *S. dissimile*. In *S. attenuatum* the longitudinal ridges, instead of being rounded and regular, are much flattened and vary in width on the occludent portion of the valve; the majority of those on the inner half are

[1] Description of section, C. P. Chatwin & T. H. Withers, "The Zones of the Chalk in the Thames Valley between Goring and Shiplake": Proc. Geol. Assoc., 1908, vol. xx, p. 394.

broad, while on the outer half they are mostly very fine. The carinal portion, instead of being ornamented with slightly flattened longitudinal ridges, has extremely fine longitudinal lines. It differs further in other characters, the most important being that the scutal margin is sinuous, while it is practically straight in *S. dissimile*. *S. dissimile* may also be compared with the tergum from the Cenomanian (Korytzaner Schichten) of Kamajk, Bohemia, represented in the figure given by J. Kafka[1] (1886), and assigned by him to *S. tuberculatum*, Darwin. This tergum agrees in having a number of raised longitudinal ridges radiating from the apex, but disagrees, among other characters, in that the valve is not conspicuously divided into two parts by a prominent ridge, and in the absence of a groove extending from the apex to the scutal margin.

In conclusion I wish to thank the following gentlemen for help in connexion with this paper: Dr. F. A. Bather, Mr. C. P. Chatwin, Dr. A. W. Rowe, and Mr. C. Davies Sherborn.

IV.—The Geology of the Dolgelley Gold-belt, North Wales.

By Arthur R. Andrew, M.Sc., F.G.S.

1. Introduction.
2. Previous Literature.
3. Stratigraphy.
4. Structure.
5. Petrology.
6. History and Statistics of Mining.
7. Lodes of the Dolgelley Gold-belt.
8. Summary of the Veins.
9. Genesis of the Auriferous Veins.
10. Bibliography.

Introduction.

The town of Dolgelley lies slightly outside the main tract of gold-bearing country of Merionethshire, but it forms a convenient headquarters from which to visit the various gold-mines and auriferous lodes. The Dolgelley Gold-belt lies within the area covered by the quarter-sheets 27 N.E., 27 S.E., 32 S.E., 33 N.W., 33 N.E., 33 S.W., 36 N.W., 36 N.E. of the 6 inch Ordnance Survey maps of Merionethshire. It is on the north side of the estuary of the Mawddach, extending from the sea at Barmouth to the locality of Gwynfynydd on the north-east. The belt forms the south-eastern flank of a range of high ground sloping down to the south and south-east from the mountains of Rhinog, Diphwys, and Garn. It is drained by several tributaries of the Mawddach, of which the principal are the Afons Hirgwm, Cwm-llechen, Cwm-mynach, Wnion, Las, Gamlan, Eden, and Gain.

The rocks of the Gold-belt all belong to the Cambrian System, and are of two main lithological types—

(1) The greywacke set of the Harlech Grits of H.M. Geological Survey.

(2) The shale set of the Lingula Flags of H.M. Geological Survey: the lowest bed of the latter is usually separated out as a distinct zone, the Menevian.

Previous Literature.

A considerable amount of literature has accumulated, dealing with the stratigraphy, palæontology, petrology, mineralogy, and also the

[1] "Přispěvek ku poznáni cirripedů českého útvaru křidového": Sitz. Ber. k. Böhm. Ges. Wiss., Prag, 1885, p. 565, pl. i, fig. 7.

mining of the district under review. A brief résumé of this literature will now be given, and a full list of references will be found at the end of this paper.

Stratigraphy.—The rocks of the district were first mentioned by Murchison (7) and Sedgwick (3), and formed part of the formations under dispute in the famous Cambro-Silurian controversy. Sedgwick's final classification was as follows, and in so far as it applied to the rocks of the Gold-belt it is that accepted to-day :—

3. Bala Group (Upper Cambrian).		
2. Ffestiniog Group (Middle Cambrian) . .	(*c*) Arenig Slates.	
	(*b*) Tremadoc Slates	which form the Dolgelley area.
	(*a*) Lingula Flags	
1. Longmynd and Bangor Group (L. Cambrian) .	(*c*) Harlech Grits	
	(*b*) Llanberis Slates.	
	(*a*) Longmynd Slates.	

Between 1850 and 1854 the whole of this Merioneth area was mapped by the officers of the Geological Survey, and in 1854 appeared their geological maps (on a scale of 1 mile to 1 inch): these have not yet been revised (11). In 1866 there appeared the first edition of the Geological Survey Memoir of the district (12). A new edition of this memoir, published in 1880 (13), contained some changes in the classification employed. The Tremadoc Slates were separated from the Lingula Flags, with which they had previously been associated, and at the same time the term Menevian was first used by the Survey, for the band of black shales and slates at the base of their former Lingula Flags. The sequence of the Survey became—

4. Tremadoc Slates	Upper Cambrian.
3. Lingula Flags	Upper Cambrian.
2. Menevian Slates	Middle Cambrian.
1. Cambrian Grits and Flags . . .	Lower Cambrian.

From 1846 to 1867 a certain amount of investigation was carried out, chiefly by Sharpe (16), Readwin (29), Salter (20), Plant and Williamson (23), Belt (24). Most of these investigations resulted in proposals of new classifications of the rocks, but on the whole these proposals have not been accepted. The chief of the investigators was Thomas Belt, who introduced the splitting of the Lingula Flags into the Dolgelley, Ffestiniog, and Maentwrog divisions—a grouping which is in use to-day. Belt's sequence consisted of—

10. Tremadoc Slates.
8 and 9. Upper and Lower Dolgelley.
7. Upper Ffestiniog: Tough blue-grey flags.
5 and 6. Lower Ffestiniog: Blue and brownish-grey fine-grained flags, the lower part slightly arenaceous and micaceous.
3 and 4. Upper Maentwrog: Dark-blue slates weathering rusty, the lower part yellowish and bluish-grey fine-grained flags, sometimes a little arenaceous, but not so coarse as the groups still lower.
1 and 2. Lower Maentwrog: Blue-grey and blue-black jointed slates with slightly arenaceous flags, the lower part grey, and yellowish-grey pyritic flags with hard felspathic bands.
0. Lower Cambrian, consisting of—
(*c*) Menevian with *Paradoxides*.
(*b*) Harlech Grits.
(*a*) Bangor Slates.

From 1867 to the present day, except the second edition of the Survey Memoir, 1881, nothing additional has been published.

Within the last ten years, however, Professor Lapworth and Dr. T. Stacey Wilson have mapped much of the Merionethshire country and determined the sequence and general distribution of the various lithological groups of the Lower Cambrian of the region. Although their work has not yet been published, they permitted me to use their results and showed me through their succession from the Cefn Slate Group to the top of the Vigra Beds. The following is the descending sequence of Lapworth and Wilson as employed and referred to by myself in the present paper:—

Lowest Lingula Flags of the Geological Survey.	9. Ffestiniog Beds of Belt. 8. Pen Rhos Beds (Upper Maentwrog of Belt): Dark-blue slates characteristically weathering to a bright-red or perhaps rusty colour. 7. Vigra Beds (Lower Maentwrog of Belt): Dark-grey and blue slates, with numerous interstratified hard beds of felspathic and siliceous material, which occur throughout.
Menevian of Survey.	6. Clogau Beds (Menevian of Salter and Belt): Black shales and slates.
Harlech Grits of Survey.	5. Gamlan Shale Group: A succession of grey, greyish-green, and sometimes purple shales, slates, and flags, interbedded with occasional grit bands, which increase in number and thickness on going eastwards; thickness 750 to 1200 feet. 4. Barmouth Grits: Massive felspathic grits or greywackes with pebble bands; say 600 feet thick. 3. Hafotty or Manganese Shale Group (with the well-known persistent zone of manganese ore at the base): Grey and green shales and flags; to the west with rare grits; to the east the grits become more frequent and eventually coarse and thick-bedded; total thickness about 1000 feet. 2. Rhinog Grits: Massive grits forming the Rhinog and other mountains; thickness about 2500 feet. 1. Cefn or Llanbedr Slate Group: Blue and purple shales, flags, and slates; to the west (Egryn, Llanfair) with occasional grit bands; to east (Cefn Cam, etc.) the grits are more abundant, and the lowest beds (Dolwen) are red felspathic grits and shales.

Palæontology.—The district around Dolgelley had always been considered destitute of fossils until in 1864 Readwin found *Paradoxides Davidis*, which was described by Plant (22). This, together with the discovery of *Anopolenus* and *Theca*, enabled the lower beds in which they occur to be cut off from the higher beds in which are found the *Olenus* and *Lingula* of the Survey. In 1866 Plant discovered a considerable number of fossils (21–3). In 1867 Belt's examination led to the discovery and identification of many additional genera and species (24). Many fossils too had been discovered by the officers of H.M. Geological Survey. The following table contains the names of all fossils that have been discovered in the Dolgelley area and in the immediately neighbouring country. In this list 'P' means that the fossil was reported by Plant, 'B' by Belt, 'S' by the Survey.

From the Ffestiniog Group of Belt; the Hafod Owen of Plant.

B	*Conocoryphe micrura* (Salt.) (from Upper Ffestiniog).
P	*Conocoryphe* sp.
B, S	*Hymenocaris vermicauda* (Salt.).
P	*Olenus* sp.
B, P, S	*Lingulella Davisii* (McCoy).
B	*Bellerophon cambrensis* (Belt) (from Upper Ffestiniog).
P	*Buthotrepis* (?).

From the Pen Rhos Beds; the Upper Maentwrog of Belt.

B	*Agnostus pisiformis* (Linn.).	B	*O. truncatus* (Angelin).
B	*Olenus cataractus* (Salt.).	S	*O.* sp.
S	*O. micrurus* (Salt.).	S	*Lingulella Davisii* (McCoy).

From the Vigra Beds; the Lower Maentwrog of Belt; the Cwm Eisen of Plant.

S	*Agnostus nodosus* (Belt).	S	*Hymenocaris vermicauda* (Salt.).
B	*A. pisiformis* (Linn.).	P, S	*Olenus cataractus* (Salt.).
P, S	*A. princeps* (Salt.).	S	*O. gibbosus* (Wahl.).
P	*A. trisectus* (Salt.).	P	*Sao hirsuta.*
P	*Holocephalina* sp.	S	*Lingulella Davisii* (McCoy).

From the Clogau Beds; the Menevian of Salter and Belt; the Tyddyn-Gwladys of Plant.

P	*Protospongia fenestrata* (Salt.).	P	*Leperditia* sp.
P	*Dictyonema* sp. (?).	P, S	*Microdiscus punctatus* (Salt.).
P	*Agnostus Davidis* (Salt.).	P	*Paradoxides Davidis* (Salt.).
P	*A. pisiformis* (Linn.).	P	*P. Forchhammeri* (Angelin).
P	*A. princeps* (Salt.).	P, S	*P. Hicksii* (Salt.).
P	*A. trisectus* (Salt.).	P	*Lingulella ferruginea* (Salt.).
P	*A. rex.*	P	*Obolella* sp.
P	*Anopolenus Henrici* (Salt.).	P	*Obolus* sp.
P	*A. Salteri* (Hicks).	P	*Theca corrugata* (Salt.).
S	*Conocoryphe* sp.		

Petrology and Mineralogy.—References to the petrology of the igneous rocks of the district will be found in the writings of Salter (20, p. 2), Forbes (25, 26, 27), and Teall (28).

A large number of minerals have been reported at various times from Merionethshire, chiefly by Readwin (30, 31), Forbes (25, p. 226; 27), and by Huddart (35). A list of these minerals is given below: unless otherwise indicated, the report of the occurrence of the mineral is to be found in one of Readwin's notices.

Native Elements: Gold, Electrum, Silver, Platinum, Platiniridium, Iridosmine, Copper, Lead (*Forbes*), Antimony, Bismuth.

Sulphides, Tellurides, etc.: Orpiment, Stibnite, Bismuthinite, Tetradymite, Galena, Sphalerite, Erubescite, Pyrrhotite (*Huddart*), Pyrites, Chalcopyrite, Marcasite, Arsenopyrite, Berthierite, Tetrahedrite, Aphthonite, Polytelite (*Forbes*).

Oxides: Quartz, Arsenolite, Senarmontite, Magnetite, Titanoferrite, Rutile.

Carbonates: Calcite, Dolomite (*Forbes*), Ankerite (*Forbes*), Chalybite (*Forbes*), Rhodochrosite, Cerussite, Malachite.

Silicates: Orthoclase, Hornblende, Uralite, Mica, Chlorite (*Forbes*), Ripidolite, Talc.

Phosphates: Pyromorphite, Mimetite.

Sulphates: Barytes (*Forbes*).

Mining.—In 1844 Dean (36) and Roberts (37) published the first notices relating to the discovery of gold in Merionethshire. During the years 1870 to 1880 Readwin published many articles in the *Mining Journal* and elsewhere, giving many details of the mining industry (32, 33). In 1902 Maclaren (38) brought together many interesting facts regarding the Merioneth field. Other references to the mining industry of Merionethshire are to be found in the writings of Forbes (25), Booth (39), Huddart (35).

Stratigraphy.

The divisions and groups which have been adopted in the present paper are those of Lapworth and Wilson for the Lower Cambrian and those of Belt for the Upper Cambrian, as far as they have been generally accepted. The grouping therefore is—

	Tremadoc Slates	Upper Cambrian.
	Dolgelley Beds	
	Ffestiniog Beds	
Pen Rhos Beds Vigra Beds	Maentwrog Beds	
Clogau Slates .	. Menevian . .	Middle Cambrian.
Gamlan Shales Barmouth Grits Manganese Shales Rhinog Grits Cefn Slates	Harlech Grits .	Lower Cambrian.

The order above is in the descending sequence of the beds. Of the formations enumerated, those which are more intimately connected with the occurrence of the auriferous lodes are the Gamlan, the Clogau, the Vigra, the Pen Rhos, and the Ffestiniog. These merit more detailed notice.

Gamlan Beds.—In the north-east part of the district, from the neighbourhood of the Afon Gain to near Blaen-y-cwm in the Wnion Valley, the lithological break between the Clogau and the Gamlan Beds is quite sudden, the black Clogau Slates extending down with all their usual characters to a basement grit (the Cefn Coch Grit), and the grey and grey-green beds of the Gamlan Group coming immediately below. In the western part, from Blaen-y-cwm to Barmouth, there is a more or less marked zone of transition, never more than 30 feet in thickness, in which there is an apparent commingling of the dark shales of the Clogau and the grey, green, and purple bands of the Gamlan. It would seem, therefore, that the grit disappears as such to the westward: almost everywhere, however, the boundary-line between the two types of Gamlan and Clogau Beds can be drawn fairly sharply.

In the north-east country the thickness of the Gamlan Group is 1200 feet, made up of intermingled grits, greywackes, flags, and shales. Following the outcrop of the rocks towards the south-west, the grits and greywackes become thinner and thinner, and the collective thickness of the beds less and less, until in the neighbourhood of the Afon Hirgwm most of the coarse-grained beds have disappeared, and the total thickness of the formation has become 750 feet. In this vicinity there is a grey flaggy bed near the top of the formation, characterized by the occurrence in it of good cubic crystals of pyrites, as much as half an inch along the edge. Traced further still to the south-west, the grits and greywackes become still finer, and near Barmouth the Gamlan Beds are seen to be made up entirely of shales and flags.

The Gamlan Shales contain numerous interbedded sills of greenstone. Towards the west, where the group consists chiefly of shales and flags, the sills are thinner than they are towards the north-east, where the greywackes are more frequent and massive. The massive greywackes would offer greater resistance to the folding forces, and would tend to form mighty buckles with large cavities between. The softer flags and shales would fold and pack more readily, and would not have rigidity enough to support massive arches. The cavities formed would be smaller and less continuous, and this difference would be represented by the difference in the size of the greenstone sills that we see to-day.

Clogau Slates.—These consist of a thickness of 250 feet of well-cleaved slates, dark-blue and black in colour. The streak obtained by scratching, however, is never really black, and as the beds in many places are greyish blue it seems difficult to justify the epithets 'jet-black' and 'intensely black' applied by nearly all those who have previously referred to them. The slates weather to a dull crumbly ochreous yellow colour on the surface. Their dark internal colouring is due to organic matter and to iron sulphide, both being present in greater abundance than in the correspondingly black slates of the Pen Rhos Beds. On analysis I found that the Clogau Slates contained the following:—

Organic matter	5·78
Iron in the form of sulphide	21·88
Not determined	72·34
	100·00

The Clogau Slates do not give rise to surface features, and are seen to advantage only in the stream courses, especially in the bed of the Afon Gamlan, above its confluence with the River Mawddach. Further up the Mawddach, close to the Tyddyn-Gwladys mine, they cut across the river and are well exhibited. Other good localities are found in the course of the Bontddu stream from the St. David's Gold Mill to the Pont-ty-glan-afon; in the workings of the Clogau lode and on the Clogau Hill; and at Aber-Amffra Harbour close to Barmouth, where the beds are exposed on the roadside.

The Clogau Slates are interleaved with numerous thin pyritous bands, usually about $\frac{1}{8}$ inch in thickness, which are rarely discernible at outcrops on the hillside, but are quite plain in the stream-courses. When fresh these bands are but slightly paler in colour than the dark-blue slates with which they are bedded; but on weathering they turn white and show up very distinctly on the smooth water-worn beds of the streams. The cause of this peculiar weathering is probably the much greater proportion of pyrites contained in the white bands. On weathering, the pyrites sets free ferrous sulphate and sulphuric acid, and the latter may dissolve out some of the coloured constituents of the slate.

The Clogau Slates are interbanded with many sills of intrusive greenstone: a few of these are massive, ranging up to 100 feet in thickness, but the majority are much thinner, often as thin as 2 or 3 feet. The strike of the thinner sills is irregular: they show a tendency to cross a few of the planes of bedding, and then resume their original course.

Maentwrog Beds.—These lie above the Clogau Slates and have a thickness of about 2700 feet: they consist of dark-grey, dark-blue, and black slates and flags. There occur throughout them numerous bands of fine-grained siliceous grit. In the upper division of the Maentwrog Group, these are present only as thin wavy white layers, from $\frac{1}{4}$ up to 2 inches thick. In the lower division, however, they increase in individual thickness to 2 or 3 feet, and occur as hard ribs sufficiently resistant to form surface features, and numerous enough to make up 25 per cent. of the actual thickness of the formation, as it is exposed in the Bontddu Glen and in the bed of the Mawddach River near the Cefn-deuddwr Gold Mine. The very great predominance of these ribs in the Lower Maentwrog is the lithological character which has been utilized by Lapworth and Wilson in separating the Maentwrog Beds into—

(*b*) Pen Rhos Beds or Upper Maentwrog.
(*a*) Vigra Beds or Lower Maentwrog.

(*a*) *Vigra Beds.*—The Vigra Beds are characterized by the large proportion of siliceous grit bands. In hand-specimens these grits are very fine-grained, homogeneous in texture, and light grey in colour; they resemble in appearance a fine-grained quartzite, and the similarity is increased by their extreme hardness.

Under the microscope it is seen that these bands are even and compact grits, the quartz grains of which are about $\frac{1}{300}$ inch in diameter. The visible minerals are quartz, muscovite, and a little felspar and pyrites. The grains of quartz are but slightly rounded, and a few may show crystalline faces: the quartz constitutes quite 95 per cent. of the total bulk of the rock. The microscopic structure of the flaggy beds in the Vigra Group is similar to that of the grit bands, but the flakes of muscovite are much more numerous and are arranged more or less parallel to the bedding.

The shales, slates, and flags with which the grit bands are interleaved are in the main similar in lithological characters to the slates, etc., in the overlying Pen Rhos Beds, but the harder ribs seem to a great extent to have protected the shales from cleavage, with the result that well-cleaved slates are seldom found. The colour of these interbedded shales and flags is dark grey and dark blue; the proportion of iron in them is somewhat less than in the Pen Rhos Beds, and the characteristic reddish weathering of the latter is generally wanting. Where exposed to atmospheric agencies the shales and flags weather easily from the outstanding grit bands. Many of the flaggy beds and a few of the grit bands weather more readily along certain lines which are not visible in the unweathered specimen, and the weathered surface becomes covered with curling ridges and furrows, which rather resemble tattooing. The type locality for these Vigra Beds is on Vigra Hill, which lies immediately north-west of Bontddu village. Good exposures are seen along the road which leads from Bontddu Post Office to the St. David's Gold Mill, and in the Bontddu stream parallel to this road. Other good exposures are in the bed of the Afon Cwm-Mynach above the Cambrian cottage, and in the bed of the Mawddach River upwards from its junction with the Afon-Eden.

(*b*) *Pen Rhos Beds.*—The Pen Rhos Beds are 1600 feet thick. They consist of shales and slates, always dark blue or black in colour; they are well cleaved, the cleavage usually being strong enough to efface the planes of bedding. They contain a few bands of siliceous grit, but compared with the Vigra Beds these are very rare indeed. Owing to the relative softness of the Pen Rhos Beds they do not form prominent surface features, except where hardened by contact with igneous intrusions. The dark colour is due to finely disseminated organic matter and pyrites, the latter of which weathers to iron oxide and gives the slates a characteristic red coloration on exposed surfaces. On fresh specimens of the slates, cubes of pyrites may be seen up to half an inch in size. On analysis these slates gave me the following:—

Organic matter	3·90
Iron in the form of sulphide	12·48
Not determined	83·62
	100·00

The Pen Rhos Beds are best seen on the Pen Rhos Hill opposite the Tynygroes Inn, 5 miles up the Mawddach Valley from Dolgelley. Numerous sections are also exposed in the road cuttings along the turnpike road from Llanelltyd to within 2 miles of Barmouth.

Throughout the Maentwrog Group there are numerous igneous intrusions; these belong mostly to the so-called 'greenstone' of H.M. Survey, but some of them are hornblende porphyries. They are mostly sills, with a great extent in strike and dip, but never more than 100 feet in thickness.

Ffestiniog Group.—This group consists of over 3000 feet of grey and grey-green flags, with a few black shales and flags; they are hard and resistant and usually form fairly high ground. Among these grey and grey-green Ffestiniog Flags there are numerous harder ribs from 18 inches down to 1 inch and less in thickness. These are of two types: many of them are greywackes of medium grain; many are compact, fine-grained, and very siliceous grits, similar to those which constitute so large a proportion of the Vigra Beds described above. Where the shales and flags are dark-coloured they contain a large amount of iron, and their weathering causes the rock to assume reddish and dun colours. They are well seen along the road which runs past the mill of the Glasdir Copper Mine up the south bank of the Afon Las as far as Pont Llamyrewig. Good sections also occur in the workings and at the outcrops of the Glasdir Copper Mine, and the gold mine of Ffridd Goch. Many very massive igneous intrusions occur among the Lower Ffestiniog Beds, such as those forming the hills behind Penmaenpool, and also the heights of the Precipice Walk, Ffridd Goch, and Moel Cerniau.

Structure.

The Dolgelley Gold-belt lies on the east and south flanks of the well-known Harlech dome of Merionethshire. The great north and south sag between its two main arches, and which Lapworth and Wilson have followed from Moel Gedog, south of Talsarnau in a broken line through the Harlech uplands, continues into this country, and enters the Barmouth estuary close to the Caerdeon Vicarage. From the neighbourhood of Gwynfynydd southwards to near Llanelltyd, the general strike of the beds is about 10° east of north. From

Llanelltyd westwards to Barmouth the general strike is in the main more north-easterly (45° or 50° east of north). This general flanking structure is much complicated by the minor folding to which the strata have been subjected. This folding has given rise to minor anticlines and synclines, often broken by small faults, especially along their axes, where, instead of yielding to the pressure by bending, the strata have snapped.

The faults found in this district may be divided for convenience into two classes—

(*a*) Minor faults or fractures.

(*b*) Major faults or throw faults.

The minor faults have probably been formed during the upheaval of the dome. They occur along those lines where the beds have been fractured, but where the pressure to which they have been subjected has not been sufficient to produce a relative displacement of the beds on the two sides of the fault. Among the harder beds of the Lower Cambrian they are especially numerous, crossing one another at all angles. In the beds of the Middle and Upper Cambrian they are not so frequent, as the strata there are not so massive, and have been more readily thrown into folds. Each of these fractures forms a noticeable groove along its outcrop.

Of the major faults or dislocations there are two main sets, with a third less important set—

1. East and west faults (practically 70° E. of N.).
2. North-east and south-west faults (30° E. of N.).
3. North and south faults.

1. *East and West Faults.*—These are almost certainly older than the others, for they are sometimes cut and dislocated by them. The most conspicuous one of this east and west set is the Cwm Mynach fault, which cuts out a great amount of the Lower Cambrian rocks. At its western end it is seen in the Maentwrog Beds; going eastwards it increases in throw, and on the Clogau Hill it cuts out fully one-half of the Gamlan Beds. As the fault is traced eastwards, it decreases in amount, and then disappears; it cannot be seen more than 5 miles away from its westerly extremity.

2. *North-east and South-west Faults.*—Instances of this set of faults are seen in the country behind Bontddu, but the displacement they cause is by no means large. They are probably contemporaneous with the north-east and south-west gold-lodes, for at Bwlchcochuchaf and Hafoduchaf there is a close relationship between one of these faults and the lodes which I describe later under these names. The north-east and south-west faults were formed after the east and west ones, as is seen in the country behind Bontddu.

3. *North and South Faults.*—These are the most recent and conspicuous of the faults of the Dolgelley Gold-belt. They are found throughout the district, but are of greatest importance towards the north-east. The chief faults of this set are the following:—

(*a*) The Llynbodlyn fault of Lapworth and Wilson extends from the estuary at Caerdeon to Llynbodlyn on the west of Diphwys, a distance of about 4 miles. It cuts several lodes and causes a considerable displacement of the sedimentary beds.

(*b*) The Bryntirion fault is about 2 miles long: it attains its maximum importance on the Clogau Hill, where it intersects the Clogau or St. David's lode.

(*c*) The Afon Gain fault runs along the course of the Afon Gain, and extends north and south from there. Its effect is greatest in the north, and it dies away to the south in the Maentwrog Beds, faulting the Gwynfynydd lode on the way.

(*d*) The Beddycoedwr fault passes down the east side of Moel Gwynfynydd. Like its companion, the previous one, it decreases in intensity towards the south, dying out finally in the Ffestiniog Beds. It cuts out all the Pen Rhos Beds, and a small part of the Vigra Beds. The eastern end of the Gwynfynydd lode terminates against it.

Cleavage.—All the finer-grained members of the sedimentary formations of this Dolgelley Gold-belt are traversed by cleavage planes. In very few cases, however, are the resultant slates of sufficiently good quality to be utilized for roofing or similar purposes. The strike of the cleavage planes is northerly; it usually lies between the limits of 5° west and 10° east of the meridian; it exceeds these limits very rarely. The dip of the cleavage planes is always steep, from 70° to 90°, sometimes towards the east, sometimes towards the west. The direction of cleavage in the gold-belt is entirely independent of the geological structure, as expressed in the dip and strike of the beds as a whole, and also of the minor puckerings and contortions into which the slates have at times been thrown. It is quite possible that there has been movement of the country subsequent to the development of the cleavage, but it cannot have been of great importance.

The movement of the country which gave rise to the cleavage must have been subsequent to the intrusion of the greenstone masses. In several instances we find examples in which a coarse, rude cleavage has been induced in the igneous rocks themselves, in the greenstone above the Precipice Walk, Dolgelley, and further east towards Llanfachreth. Other instances may be seen near the top of Y Garn and elsewhere. In these cases of cleaved greenstone, the direction of cleavage is the same as that of the finer general cleavage which traverses the slates. I have met with one case where the greenstone intrusion has an included band of shale hardened to such an extent that it had resisted the cleaving force and has remained uncleaved. It is possible that it may have been more or less protected by the great thickness of igneous rock in which it is enveloped, but the conclusion remains the same—that the greenstone was there before the cleavage commenced. This example is seen on the Clogau Hill, north of Bontddu, just where the old mine tramway crosses the large sill which runs from Llechfraithisaf up to the top level of the St. David's Gold Mine.

Although the intrusion of the greenstone is previous to the cleavage of the country, I believe that it is subsequent to the folding. In several cases where the rocks are puckered and folded, it is seen that the greenstone sills do not continue uninterruptedly round the folds, but feather out at the actual bend of the folds, the form of the intrusion being here determined by the pre-existing form of the folding.

Again, the intrusion of the greenstone appears to be subsequent to the movement of the country which caused the formation of joint-planes. Some distance up the Bontddu stream, 200 yards above the St. David's Gold Mill, a sill of greenstone is seen to end abruptly at a joint; there is absolutely no trace of movement having taken place along this joint-plane, and of the sill being faulted off. It therefore seems that the joint-plane was there before the greenstone was intruded, and was the determining factor in its abrupt termination.

The general sequence of events in this district after deposition thus appears to have been—(1) folding and jointing, (2) intrusion of igneous rocks, (3) cleavage. In this district there is no evidence to show the actual geological date of origin of these separate phenomena. In the North Wales region generally, however, it is considered certain that the cleavage of the region was effected in the interval between Silurian and Carboniferous times. In the North Wales region, the igneous rocks found among the Ordovician beds are believed to have been intruded in late Ordovician or Silurian times, and the greenstones of the Dolgelley Gold-belt were probably intruded at this time also.

According to Ramsay, the sequence of the movements in North Wales generally was — (1) intrusion, (2) folding, (3) cleavage. I think, however, that in the Dolgelley area the folding preceded the intrusion of the sills, but the point is not of great importance, as it is most probable that the two phenomena were closely associated, and took place at very nearly the same period.

Petrology.

Throughout the district in which the gold-bearing lodes of the Dolgelley Gold-belt occur, there are many intrusions of igneous rock, several of them of considerable magnitude. These intrusions occur in the form of dykes, of sills, and of more massive bosses. Dykes are by no means common and the only clearly defined examples occur in the country at the back of Bontddu. The sills are found most frequently among the soft yielding shales. In the softest formation of all, the Clogau or Menevian, they are very numerous, and have such a considerable aggregate thickness that in places they 'fatten out' the Clogau Beds by fully 50 per cent. The sills constitute far and away the greatest proportion of the igneous rocks of the district; they range in thickness from tiny interbeddings 6 inches wide, such as occur a short distance below the Vigra bridge, Bontddu, up to massive, almost laccolitic intrusions, 200 feet thick, such as form the conspicuous ridge at Llechfraith on the Clogau Hill. The sills continue quite evenly between the bedding planes for considerable distances before they die out. At times, however, they break across the bedding, and their intrusive and subsequent nature is thus clearly demonstrated.

The metamorphic effect of these igneous intrusions upon the rocks with which they come in contact is not very considerable. The shales are baked into hard porcellanites, but only for a short distance (a maximum of a few feet) from the intrusions. On weathering, these baked shales project from the softer unchanged shales, and also as a rule from the intrusive rocks themselves. The black shales are to a certain extent decolorized by the baking.

I believe that in this district the igneous rocks all belong practically to the same period. There is no great diversity of lithological character among them, and they probably originated in the same common magma. The petrographical character of the igneous rocks is difficult to determine, the metamorphic action to which the rocks have been subjected has been sufficient to destroy and change the characters of many of the minerals of which they are composed. There are two types of igneous rock represented in the district: (1) Diabase (of Harker, Teall, etc.); (2) Porphyry (of Rosenbusch).

Among the diabases are practically all the 'greenstones' of H.M. Geological Survey. (The name 'greenstone' is so convenient for referring to the diabases that I have used it almost invariably throughout this paper.) The structure of the rock is intermediate between the plutonic and the volcanic types, though there is considerable variation and gradation in structure. The minerals that occur in the rock are oligoclase, hornblende, uralite, pyrrhotite, pyrites, chalcopyrite, calcite, sericite, kaolin, and iron oxides. Plagioclase forms the most conspicuous phenocrysts in the rock; the crystals, rounded in outline, are twinned—chiefly albite twins; the plagioclase is probably a basic oligoclase close to andesine; the felspar phenocrysts are always cloudy, the cloudiness being due to the presence in them of weathering products such as calcite, kaolin, etc., the individuals of felspar range down in size to minute lath-shaped crystals, which make up a large proportion of the ground-mass of the rock. Hornblende is seldom seen to satisfaction, it occurs among the phenocrysts, where it is intensely brown and strongly pleochroic; usually the hornblende is completely decomposed into sericite and chlorite. Pyrites, pyrrhotite, and chalcopyrite are very abundant in the rock, but as far as my examination goes, there is no evidence to determine whether these minerals were originally present in the rock or have been subsequently introduced. Chlorite, sericite, kaolin, and iron oxides are found among the decomposition products of felspar and hornblende, but their characters call for no special mention. The specific gravity of this diabase rock is 2·84; it should be noted that the felspar is oligoclase, which is rather too acid a type of plagioclase to be usually found in a diabase.

The second type of the igneous rocks of this Gold-belt is a porphyry or uralite porphyry; it is of much more restricted occurrence than the diabase, and I know of only two outcrops where fresh specimens may be obtained; these are at Y Garn and at Cefn-deuddwr. The Y Garn rock is typically porphyritic, the phenocrysts consisting of orthoclase, uralite, and hornblende, the latter much decomposed; the ground-mass is fine-grained and microcrystalline, and is densely packed with little squares of orthoclase, which, like the phenocrysts, present only the usual characters. The only other minerals in the rock are muscovite, chlorite, and pyrites, produced by the decomposition of the hornblende; the specific gravity of the rock is 2·738.

The Cefn-deuddwr rock differs from that occurring on Y Garn in the much greater size and abundance of the phenocrysts of uralite, hornblende, and orthoclase, and in its coarser texture; the individuals may be as much as 1 inch in length. The rock is composed of orthoclase, plagioclase, hornblende, uralite, chlorite, magnetite, calcite, and pyrites. Orthoclase is found in large amount both in phenocrysts and in the ground-mass. In the former it often shows a clearly marked arrangement of concentric zones on the external margin of the crystal; the orthoclase is usually cloudy, owing to the presence of calcite. Plagioclase is present sometimes, but never to such an extent as the orthoclase; it is confined to the ground-mass, where it occurs as lath-shaped albite twins, probably andesine. Hornblende, like the orthoclase, occurs in two generations, among the phenocrysts and in the ground-mass; it is brown and strongly pleochroic. The bulk of the coloured constituent of the rock is uralite. Magnetite is a decomposition product of the hornblende, occurring along the cleavage cracks of the smaller hornblende crystals and giving a lattice-like appearance to the mineral. Pyrites may at times be very abundant in the rock, but often it is quite absent: it is perhaps of secondary origin.

It is to be noted that Forbes in 1868 (27) reported and described a uralite porphyry from this neighbourhood.

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

V.—On Coral Zones in the Carboniferous Limestone.

By R. G. Carruthers.[1]

AMONGST the corals collected by the Geological Survey during the past season, and submitted to me for determination, two specimens call for special remark, since they appear at first sight to occur out of their true zonal position. They were found by Mr. Dixon on the Pembrokeshire coast, to the south and south-west of Castle Martin. In each case Mr. Dixon gives the horizon as C_2–S_1, in the terms of Dr. Vaughan's classification. They are, accordingly, of Lower Visean age.

One of the specimens (E.D. 1253) is referable to the genus *Dibunophyllum*. In cross section there is a general resemblance to the figure of *Dib.* aff. ψ recently given by Mr. Douglas.[2] In the Pembrokeshire specimen, however, the mesial plate, although conspicuous, is not thickened in the middle, and the central area is more clearly separated from the septa. In vertical section the central and tabular areas are sharply differentiated, the former being crowded with fine vesicles directed inwards and upwards at a steep angle.

The second specimen (E.D. 1350) is an example of *Cyathaxonia rushiana*, Vaugh. A cross section shows the characteristic columella, relatively large, oval, and with a 'lath' in the centre.

Hitherto, *Dibunophyllum* has not been recorded in the British Isles below the *Dibunophyllum* zone (D), while *Cyathaxonia rushiana* has only been found at a still higher horizon in the uppermost Visean,

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

[2] J. A. Douglas, "The Carboniferous Limestone of County Clare": Q.J.G.S., 1909, vol. lxv, pl. xxvii, fig. 6.

i.e. in the *Cyathaxonia* or D_3 sub-zone. It must be remembered, however, that *C. rushiana* shows a close approximation to the well-known Tournaisian coral *C. cornu*, Mich., and that the *Dibunophylla* are not widely differentiated from many of the Clisiophyllids found in Lower Visean, Upper Tournaisian, and Upper Devonian beds.

The discovery of these two fossils at a Lower Visean horizon adds another link to a chain of evidence bearing on the nature of the zones adopted for the Carboniferous Limestone. Facts have now accumulated in sufficient number to warrant a brief discussion of the value of these zones as time indices. In this respect, without wishing to criticize unduly a zonal system whose application to stratigraphical problems has met with much success, it is nevertheless desirable that the limitations of the system should be pointed out.

So far as the corals are concerned, it must be said that the zones are not based upon the presence of forms which are in true genetic sequence so much as upon a succession of unrelated faunal phases. They are, in fact, dependent upon a series of physical conditions (not of necessity expressed lithologically), each of which is favourable to certain gentes only. Almost invariably a gens flourishing at one particular level is not found in the beds immediately above or below, but reappears after a considerable interval in a more or less modified form. Abundant illustrations of such a fact are supplied by the distribution of the corals in the South-Western and Midland Provinces. Thus it is found that the gens of *Cleistopora geometrica* disappears entirely above the *K* zone, unless it recurs at the top of the Visean under the guise of *Paleacis cyclostoma*. Again, the gentes of *Zaphrentis delanouei* in Z_1, and of *Z. omaliusi*, *Caninia cornucopiæ*, and *Cyathaxonia cornu* in Z_2, γ, and C, are not again found above those zones until the highest Visean beds are reached. They then reappear in the D_3 or *Cyathaxonia* sub-zone in a series of mutational forms (in Waagen's sense), whose difference from the parent stock is not great, considering the interval of time that has elapsed.

The sudden and abundant appearance of *Caninia gigantea* in γ, of *Lithostrotion junceum*, *Lonsdaleia floriformis*, and many other members of the rich Upper Visean fauna, also cannot be accounted for by any observed genetic connexion with immediate predecessors, but must probably be ascribed to immigration. It cannot be said that ancestors of these forms have been found in the preceding zones, although in all probability they are present in the Clisiophyllids and the simple and compound *Cyathophylla* of the Upper Devonian. Many other instances of a similar nature might be given, but their enumeration is scarcely necessary for our present purpose.

The explanation of these phenomena seems to lie in an application of the old theory of 'colonies', the various gentes having lived in outlying areas until conditions favourable to their existence recurred. It is not for a moment to be denied that over a very large area, embracing the South-West of England, North and South Wales, the Midlands, and even the West of Ireland and Belgium, the sequence of physical conditions, and consequently of fossils, is usually in the same order. Sooner or later, however, local areas are met with where different conditions have prevailed. Consequently there is an abnormal faunal phase, and difficulties of correlation immediately arise. That is instanced in the lower part of the Rush sequence, and in the attempt to trace the subdivisions of the uppermost Visean, established in the Midland Province and in the Loughshinny coast section, through the totally different facies obtaining in the North of England and Scotland.

The objection, therefore, to a rigid stratigraphical application of those corals now regarded as of zonal value, is that the present system is dependent on the succession of a number of forms, most of which are not in genetic connexion, and of whose true range in time we have at present little or no conception. It must be self-evident that it is impossible to estimate the time value of any fossil until the evolution of the gens to which it belongs has been worked out, and the range of the various mutations ascertained. A system of zoning established on such lines may seem an impossible ideal, but it is certainly attainable in some degree. In the meantime Dr. Vaughan and his co-workers have, as a rule, utilized the general characters of the faunal assemblage as diagnostic of any particular horizon. The errors caused by the introduction of species, by favourable conditions, at a somewhat different level in the areas concerned, are in this way made partially to counterbalance each other. If, in addition, the sequence of physical conditions, and therefore of faunal phases, are in agreement, then reliance can be placed on the broader aspects of the correlations suggested. It is in this way that the unconformity within the Limestone in South Wales, and the extensive overlaps in North Wales and Yorkshire, have been demonstrated. But the fact remains that the finer details of correlation must be open to question so long as a zonal scale has to be used in which the genetic sequence is so imperfect. That is so even in areas exhibiting a similar succession of physical conditions. Even more objection applies to precise correlations based on the sudden appearance of certain gentes that are not represented in underlying beds. And it is still more doubtful whether correlations, except of the most generalized kind, can be made by existing methods, between areas exhibiting a serious difference in faunal facies. In such cases, it would seem that reliable results can best be attained by working out the evolution either of the few gentes common to both areas, or of the contrasted gentes, if they can be found together in another region. In the meantime, it is by the discovery of intermediate links, such as the two interesting corals found by Mr. Dixon in South Wales, that a zonal scale, of a continuously genetic nature, may eventually be established. The frequent discovery of such fossils need cause no surprise; on the contrary, it is only to be expected during the progress of research.

VI.—On the Occurrence of Aragonite in the Middle Lias of Leicestershire; with some remarks on the Calcareous Character of the *Spinatus* Beds.

By A. R. Horwood (Leicester Museum).

THE Liassic strata generally are so barren of any minerals of importance or of an appreciable size or extent that the record of the discovery of one not hitherto known to occur in a crystalline form, apart from the part it plays in the formation of shell-layers at that horizon, is assuredly of interest. Hitherto the Liassic strata have not yielded any minerals unassociated with shell-structure, except selenite, which occurs commonly in some Upper Liassic clays, whilst it is not unusual to find fossils converted into iron-pyrites or marcasite, especially at certain horizons. The Doggers of Yorkshire are noteworthy instances of this kind. In the Middle Lias, zinc, nickel, and cobalt are found in the iron-ores of the Cleveland district.[1]

Whilst confined hitherto, so far as I am aware, to the parts of shells, etc., which have not been converted into calcite—the usual form taken by carbonate of lime when replacing the lime secretions of shells of Mollusca and other testaceous animals—aragonite has now been discovered by the writer unassociated with organic remains in the *Amaltheus spinatus* beds of the Middle Lias, or Rock-bed, at Tilton Hill, near Lowesby Station, Leicestershire.

The mineral exhibits clearly the acute pyramids characteristic of it, with orthorhombic crystals. Although not common it forms a mass about a foot square in some places the crystals being radially arranged, as is usually the case, with their terminations all directed to a common centre, in much the same way as those of quartz in the 'potato-stones' or geodes of the Trias. But their mode of occurrence seems best compared with certain boulders of strontia, discovered by Mr. H. Bolton[2] at Leigh Court, near Bristol, the outer surface presenting an amorphous rounded exterior, characteristic of worn boulders in general.

The surface of the Tilton boulders does not, like the Triassic boulders, present grooves. I was informed by Mr. G. W. Lamplugh that the Middle Lias at Barnstone presents striæ, but these are probably not of Marlstone age, but truly Glacial (or post-Pleistocene). It is interesting to note that in typical aragonite a small percentage of strontia (4 per cent.) usually occurs. The exact horizon of these deposits at Tilton Hill is a few feet at most, usually a few inches, above the thick "encrinital limestone band", which occupies so constant a position, just below the Transition-bed, between the Middle Lias (*spinatus*-beds) and the Upper Lias. This horizon is a well-marked one, and may be traced all over the higher ground at Tilton Hill. The name "encrinital limestone band",[3] adopted from Wilson,[4] is not quite correct, since encrinites do not enter into its composition, but, as pointed out elsewhere,[5] this band is made up of joints and portions of stems of Crinoids, with fragments of *Pecten*, Polyzoa, and other littoral organisms, resembling in composition some forest marbles of the Eastern Counties, as suggested to me by Professor T. R. Jones. Perhaps a better name, more correct from a palæontological point of view, is *crinoidal limestone band*. The crinoid stems, though fragmentary, are abundant, and the horizon

[1] *Vide* Rudler, "Minerals of the British Isles": Mem. Geol. Surv., 1905, p. 191.

[2] See Geol. Mag., 1907, p. 471. These boulders varied in size from that of a pea to that of a mass 100 tons in weight.

[3] Geol. Mag., 1907, pp. 462–3.

[4] Ibid., 1886, p. 296 et seqq.

[5] Trans. Northants Nat. Hist. Soc., 1907, p. 105.

forms a distinct band in section, being highly calcareous, and in character a crystalline limestone, consisting of at least 60 per cent. of carbonate of lime. From its composition it is thus practically pure calcite. Indeed, the organic contents are mainly calcite, and the inorganic residue consists of a small percentage of lime, with iron and a little detrital matter, though in this last respect it varies a good deal.

Dr. R. Brauns[1] has pointed out that calcareous deposits may be determined in their ultimate character by the temperature of the solutions from which they are precipitated, calcite being formed with its characteristic rhombohedra in a cold solution, or one in which there is a preponderance of alkaline silicates, whilst a warm solution, and one in which gypsum or strontianite occurs, is conducive to the formation of aragonite. The amount of concentration of the solution influences the direction which the carbonate of lime will take, or its ultimate form as calcite or aragonite. Thus Credner[2] has found that a cold saturated solution produces calcite, a warm dilute solution aragonite. These conclusions are borne out, moreover, by the physical relationship between the contents of this crinoidal limestone and the strata above. Thus above this horizon the beds are more ferruginous, less calcareous, often glauconitic, and of a distinctly more littoral type, the chief characteristics of the fauna being Gasteropods, Echinoderms, and Cephalopods. These beds would thus present, when unconsolidated and in a state of solution, a warmer temperature, and because they were further from the bottom of the basin or floor of the sea would be less concentrated with calcareous matter, but would contain more alkaline silicates. Thus aragonite would here replace the carbonate of lime, which does not amount to as much as 50 per cent. And this is what is actually the case, the shells being aragonite shells, though not confined to the zone or organisms mentioned and more constant at the horizon indicated. Cephalopods, *Pinna*, *Amusium*, and others all have the outer original aragonite layer removed, and are preserved as casts, with few exceptions. In the iron-ore beds the percentage of lime is 62·14 per cent., with ferric oxide 25·71 per cent. at Caythorpe and 30 to 33 per cent. at Tilton.[3] But here and elsewhere the percentage of lime generally in the ore-bearing rock is very much lower, being about 13 per cent., whilst there is 29 per cent. of carbonic acid. In the crinoidal limestone band, however, the constituents are markedly different. Of lime there is a percentage of quite 60 per cent., and an absence of detrital matter or ferric oxide to an appreciable extent. This band, moreover, marks, as I have suggested, the culmination of pelagic and the inset of more littoral conditions. In this way it would naturally have been deposited as a more or less concentrated solution, because nearer the bottom into which all saline matter collects, and a colder solution from its abyssal character. Moreover, pure limestone usually denotes deposition far from land, and in this case the pure character may be due to absence of sandy or argillaceous matter and undisturbed deposition of lime, whilst the

[1] *Chemische Mineralogie*, 1896, p. 156.
[2] *Neues Jahrb.*, 1871, p. 288.
[3] Geol. Mag., 1907, pp. 462–3.

fragmentary character of the organisms may denote that the deposit, which is very thin but constant, owes its highly calcareous nature to its being an ancient sea-floor. The fragments are not rolled, but are broken portions that have dropped down into the abyssal depths from the higher zones. It seems, indeed, more natural to regard it as at first pelagic and gradually elevated, allowing of more littoral conditions above.

The occurrence of calcite and aragonite in the same seam, which is found in most instances to be the case where an abundant fauna occurs, is quite in harmony with known conditions elsewhere, for in the hæmatite deposits at Cleator Moor both calcite and aragonite occur.

It may be of interest here to note the distribution of calcite and aragonite when replacing carbonate of lime of shells of Mollusca or other animals. Dr. Sorby [1] has shown that the shells of some organisms are preserved as calcite, others as aragonite, whilst in some one portion is converted into calcite, the other into aragonite. And he demonstrated that certain forms—Foraminifera, Annelids, Echinoderms, Polyzoa, Brachiopoda, *Ostrea*, and *Pecten*—when preserved as fossils have their shells converted into calcite, whilst in Corals, Cephalopods, Gasteropods (except *Patella*, *Fusus*, *Littorina*, *Purpura*, etc.), Lamellibranchs (except *Ostrea*, *Pecten*, and the outer layer of *Spondylus*, *Pinna*, and *Mytilus*) the shell-layer is preserved as aragonite, if not removed by decomposition. Thus the shells and other parts of organisms from the base of the Middle Lias up to the crinoidal limestone band may be said to be largely preserved in calcite, e.g. *Ditrypa*, *Rhynchonella*, *Terebratula*, *Pecten*, and *Ostrea*, whilst *Cerithium*, *Phasianella*, *Amaltheus spinatus*, *Tropidoceras acutum*, etc., above are preserved in aragonite. Likewise *Eodiadema granulatum*, found above the crinoidal limestone band, when the test is present, is preserved in calcite, as are all the fragments of Polyzoa, *Pentacrinus*, etc., in the latter.[2]

In regard to the general character of the shell-layer in deposits of Liassic age generally, Sorby wrote: [3] "On the whole, the organic constituents of the coarser-grained beds of the Lias are closely like those of similar beds of Oolitic age, though there is a relatively less amount of fragments of aragonite shells and corals. By far the greater bulk is made up of joints of *Pentacrinus*, which in some cases constitute nearly the whole rock. Next in abundance are fragments of Brachiopods and oysters and shell-prisms; but Foraminifera and portions of Belemnites and bone also occur." Further he says: "Occasionally very crystalline, non-radiate, oolitic grains are met with, which have all the characters of re-crystallized, small, concentric, aragonite concretions."

[1] Quart. Journ. Geol. Soc., 1879, vol. xxxv, pp. 63 et seqq.

[2] See also P. F. Kendall, Geol. Mag., 1883, pp. 497 et seqq., for a further list of forms preserved in calcite and aragonite respectively in the Coralline Crag. His researches bear out in a remarkable way, as to that formation at least, those of Sorby, whilst in so far as my own observation has gone I am able to corroborate his conclusions in the case of the Middle Lias (*vide supra*).

[3] Ibid., p. 84.

The very hard character of the crinoidal limestone band, made up so largely of crinoid stems, is due to the preservation of the constituents as calcite. And it is doubtless to a similar horizon that Dr. Sorby refers above, though there is no reason for assigning them in particular to *Pentacrinus*. In a section this band stands out some distance from the beds above and below, protecting the latter from denudation. In the quarry at Billesdon Coplow the position of this band is well shown, being indicated by a marked projection near the top of the section. The section shows, moreover, the position of the Transition-bed, the horizon of *Eodiadema granulatum*, and many Gasteropods. The same band is the horizon of the aragonite boulders at Tilton Hill. The hardness of the crinoidal band is indicated by its fresh surface when transported in glacial deposits, whereas the ferruginous marlstone is generally decomposed and weathered. The oolitic grains mentioned by Sorby as consisting of aragonite concretions occur in small glauconitic pockets of the Transition-bed, and upon faces of the jointed rock. These concretions are similar in character to those found—if the deposits are of carbonate of lime—in hot-water boilers, though aragonite alone is not found. Aragonite in a crystalline mass may depend upon the distribution of water in rocks, or the water-level. Thus W. Wallace [1] found that it was only to be met with above the water-level in caverns in Cumberland. This is analogous to the distribution of aragonite as the replacing mineral in the shell-layer of fossil organisms. Messrs. Cornish & Kendall [2] found that shells in permeable strata had their aragonite layer dissolved out, whilst those protected by an impermeable layer above were preserved. To a less extent calcite is affected in the same way.

In the littoral sandy, ferruginous, and readily permeable beds of the Middle Lias Marlstone a large percentage of the aragonite shells have their shell-layer dissolved away. The aragonite boulders above the crinoidal limestone band are similarly worn externally, probably by the action of water through percolation. In the first instance they must have been precipitated in a warm solution, and consequently at a period when the surface was elevated above the level at which the crinoidal band itself was formed.

Aragonite is found in older calcareous rocks, chiefly Mountain Limestone or earlier rocks, in Cornwall, Devon, Dorset, Derby, Cumberland, Durham, and Somerset; in Scotland at Lead Hills, Galloway, Seafield, Portsoy (Banff), Shetland Islands, and Orkneys; and in Ireland in Antrim, Derry, Down, Kerry, and MacGilligan. To these localities must now be added Tilton Hill,[3] Leicestershire. The best localities are Alston Moor and Cleator Moor, where there are hæmatite deposits. As a whole it is thus characteristic of the older rocks, when doubtless the mean thermal heat was greater than in later geological times.

[1] Quart. Journ. Geol. Soc., 1865, vol. xxi, pp. 413–21.

[2] "On the Mineralogical Constitution of Calcareous Organisms": GEOL. MAG., 1888, p. 66.

[3] Though so called this locality is close to Lowesby Station (G.N.R.), and must not be confounded with the cutting near Tilton Station (joint L.N.W.R. and G.N.R.). a locality more widely known than the Lowesby one.

But the opposite appears to be the case in regard to the shell-layer, i.e. of organisms preserved in part as carbonate of lime, for in their case aragonite shells, judging from the occurrence of casts, are more typical of later than earlier deposits. In this case we must remember that the habitat of the animal will influence the replacement of its shell as calcite or aragonite—in other words, their distribution depends in each epoch upon the bathymetrical range of the organisms. But that of the crystalline masses of aragonite found in caverns and cavities in other rocks depends, according to Wallace, upon the water-level and the temperature of springs percolating through the superincumbent mass, and in large measure upon the former secular heat of the earth's crust.

REVIEWS.

I.—The Face of the Earth (Das Antlitz der Erde). By Eduard Suess. Translated by Hertha B. C. Sollas, under the direction of W. J. Sollas. Vol. IV. 8vo; pp. viii, 673, with 55 illustrations. Oxford: Clarendon Press, 1909. Price 25*s*. net.

WITH this fourth volume, which brings the total number of pages up to 2233, we have the completion of the text of Professor Suess' great, and we may well say marvellous, work. To ascertain what is known of the main features in the structure of the entire globe, to systematize that knowledge, to show the influence of successive crust-movements on the present features of the earth's surface, is but a bald account of what has been accomplished by the author, and admirably rendered into English by Miss Hertha Sollas, with the aid of her father.

Knowledge based on the sedimentary characters and life-history of the formations, on the extent of land and sea areas at different epochs, and on the influence of volcanic phenomena is fully utilized; but the dominant feature in *The Face of the Earth* is the careful study of the earth-movements and foldings to which various districts from time to time have been subjected. Some areas, like Laurentia, show little or no disturbance since Cambrian times, the strata of that epoch lying horizontal, whereas other regions have been affected by more or less complex systems of folding at successive epochs, the movements being influenced by buttresses of older rocks that have led to deflexion and overthrusting.

In the present volume attention is drawn to the arc-like curves of mountain chains, and also to the arcuate lines to be found among the Pacific islands, where the greatest abyssal depths, having the form of elongated furrows, lie in front of the outer border of the arcs. As the author remarks: "With one or two exceptions, all marine abysses which sink below a depth of 7000 meters are fore-deeps in a tectonic sense, and indicate the subsidence of the foreland beneath the folded mountains. Thus we are brought back to the question, whether the greatest deeps, like the highest mountains, are not the most recent."

With respect to deep-sea accumulations it is remarked: "We may conceive that little calcareous shells sink to the bottom in great quantity. They are dissolved at great depths, but accumulate in moderate or lesser depths. In the abysses red clay is deposited only in trifling quantity, but on those submarine elevations which rise above the level at which carbonates are dissolved, accumulation occurs. The result is an exaggeration of the relief. Thus the depths persist, while the ridges increase in height, and may even grow into peaks." Moreover: "During a long period of rest not only may a great sockle of limestone arise, but at some remote period, when the level of the ocean was higher, the deposit of limestone may even have grown up to a height above the sea-level as it now exists. It has then been denuded in terraces owing to intermittent negative movement."

Concerning the views of Darwin and Dana on atolls the author observes: "It must still be admitted that the depth of the enclosed lagoon has not yet been completely explained. Thus, the view that the crown has been built up by corals during positive movement has still some foundation."

With regard to the great African fractures it is remarked: "We must not form too rigid a conception of such troughs, as though they were strips of land let down between two parallel faults. Step faults are to be seen on Lake Tanganyika and in the lava fields which lie before Mount Kenya, on the west coast of the Red Sea also, and more to the north on Mount Lebanon and the slopes of the Jebel Ansarieh. We shall form a more correct picture if we think of these step faults as repeated on both sides, down to the middle of the valley bottom—many long strips, which become wedge-shaped below, being let down along them to unequal depths. In this way horsts have been left standing within the field of subsidence."

Considering the vast extent of the area involved it is regarded as impossible to explain the situation from local causes, and the author is led to assume the existence of tensions in the outer crust of the earth: the phenomena being due to a rending asunder caused by contraction, the fissures having opened from above downwards. The author's general conclusions with regard to dislocations of great magnitude are that they have resulted from movements caused by diminution in the volume of the planet.

Great part of the present work is taken up with an account of the influence of the Asiatic system of disturbances on the European and other areas, and the structure of the Alpine regions is described in considerable detail. The repetition of foldings along the same lines is discussed, and in the course of the work the relations between the great geological systems in different areas are dealt with. Brittany, the London Basin, the Mendips, South Wales, and Malvern all come under notice; likewise the mountain regions of North America and Northern Africa, the main features of Australasia and Polynesia, the festoons of islands, and the mountain system of the Andes.

In order fully to grasp the complicated structures and the sequence of events discussed by the author, each volume must be read steadily through with the aid of maps; and we are glad to learn that the fifth and concluding volume will comprise the plates to which reference is made in the present book, together with an index to the complete work. Without the index casual reference has been almost impossible, as the reader is confronted so often with new terms that a long search may have to be made before the explanations can be found.

We are taken round the world again and again in different portions of the work, when the author is dealing with the movements and foldings of particular ages, or with diverse types of scenery; and throughout the work, as we have already noted, there are disquisitions on many other subjects of wide interest, palæontological, lithological, and stratigraphical.

In treating of "The Depths" the author discusses the subject of Vadose and Juvenile waters: the former being the surface, ground, and artesian waters; the latter being those formed during volcanic eruptions, from hydrogen derived from the earth's interior combining with oxygen in the atmosphere. "Thus with every volcanic eruption the quantity of vadose water present on the earth's surface is increased."

The subject leads on to the origin of volcanoes, of ore-deposits, and diamond-pipes, and is followed by some account of the origin of the moon and the consequences of the occurrence of "invisible mountains" beneath the earth's surface, and the deflexion of the plummet: topics which we can only thus briefly mention.

On the subject of zones and sediments there are many observations of interest in connexion with contemporaneous sediments which differ lithologically and palæontologically in different areas; but this matter is not free from special, and not always very familiar, terms. Thus we are told (p. 151) that "purely heteropic heterotopy, i.e. a difference between contemporaneous formations at places remote from one another, always implies the existence of transitions". Further on we read: "In most cases, it is true, the sediment and the fauna change simultaneously, and it is this holisopy which facilitates the delimitation of the stages in nature." Remarks are made on the occurrence of perfectly white sediments in limestone formations, sediments devoid of the terrigenous element, and distinguished by an unusual abundance of organic remains. Again, we read of a stage in the Lias which, like that of *Schlotheimia marmorata*, for example, is only represented by a frequently interrupted crust of brown iron ore; a statement which reminds us of J. F. Blake's remark on a particular Ammonite zone which was locally so thin that there was no room in it for the zonal species.

The highly interesting researches of Professor H. S. Williams on the Devonian zones in North America and the interdigitation of different marine faunas receive attention.

In the concluding chapter, after mentioning that "we know nothing of the origin of life", the author discusses the distribution of plants and animals and climatic changes, and points out that the view of the permanence of oceanic basins is untenable. The incoming of new faunas in areas not subject to great physical disturbances is also dealt with, and the author describes certain "places of refuge", remarking: "If, however, we consider carefully the actual surface of the earth, we shall perceive that there are tracts in which terrestrial forms of life have been protected from the action of such physical changes as transgressions and mountain building, for a very long period. There are regions which since the time of the great disturbances of the Upper Carboniferous have been practically untouched by such movements, and the history of these—extending over a very long period, as a rule from the Lower Gondwána down to the present day—is solely represented by the remains of successive land floras; marine sediments are completely absent. It is true that in these places life was not exempt from the influence of climatic changes, nor from economic disturbances produced by the immigration of invading organisms, nor even from the effects of complete subsidence beneath the sea; nevertheless, floras followed one upon another in successive development, and the living world was less molested in these places than elsewhere: we shall therefore term them *asylums*."

We have referred to the author's view on the diminution of the earth's circumference. In his final sentences he remarks: "If there were even a remote tendency in the contraction of the planet to establish a new, uniform radius; if the Atlantic subsidences which cut through our most valuable asylums, have actually been produced by an effort to establish planetary equilibrium; then we should have to fear a progressive diminution of the area inhabitable by land and freshwater animals. Not life itself, but a very important, and indeed the most highly organized, part of it would be doomed to final destruction, and would be restored to the pan-Thalassa. In face of these open questions let us rejoice in the sunshine, the starry firmament, and all the manifold diversity of the Face of the Earth, which has been produced by these very processes, recognizing, at the same time, to how great a degree life is controlled by the nature of the planet and its fortunes."

II.—Memoirs of the Geological Survey.

The Geology of the Melton Mowbray District and South-East Nottinghamshire. By G. W. Lamplugh, F.R.S., W. Gibson, D.Sc., C. B. Wedd, B.A., R. L. Sherlock, B.Sc., and B. Smith, M.A.; with notes by C. Fox-Strangways, F.G.S. 8vo; pp. vi, 118, with 4 plates and 10 text-illustrations. London, 1909. Price 2*s.* 3*d.*

The area here described is largely a clay-district of Red Marl, Lower Lias, and Boulder-clay. It extends on the south from Loughborough Station, Quorndon, and Barrow-upon-Soar to Melton Mowbray, and on the north into the Vale of Belvoir; and it is perhaps most widely known as a hunting country. From a geological point of view it includes an unbroken sequence of strata from the Keuper Marls to the Lincolnshire Limestone, a series largely concealed by the Drift deposits.

The memoir is an explanation of Sheet 142 of the new series colour-printed map, which is accompanied as usual by a geological section. This does not show the oldest strata proved in the area, which comprise Coal-measures that have been reached by borings beneath

Keuper Marls and Waterstones at Ruddington, Owthorpe, and Edwalton. Detailed descriptions are given of the Secondary formations and of the fossils and zones in the Rhætic beds, Lias, and Inferior Oolite. The Gypsum in the Keuper Marls, the Lime and Cement Works at Barnstone and Barrow-upon-Soar, and the Brown Iron-ore of the Middle Lias, form the chief economic products in the strata, and a useful map is given to show the distribution of the ironstone. Among the plates are good views of the hydraulic limestones of Barrow, of a contortion in the same formation (resembling a sharp anticline that was to be seen at Rugby), and of an ironstone working at Warnatby.

A full account is given of the Glacial Deposits, and it is noted that the authors have been unable to follow the details of Mr. R. M. Deeley's rather complex classification. Three types of Boulder-clay are, however, noted, the main Chalky Boulder-clay, a grey clay derived mostly from the Lower Lias, and a red silty clay derived apparently from the Keuper Marl. The variations in the Boulder-clay and the distribution of included boulders are marked on a small map. The evidence shows that the ice-flow was mainly from N.E. to S.W.

The whole of the area is in the Trent drainage system. The older river gravel is considered to represent late Glacial flood-deposits, and from them remains of mammoth have been recorded. The newer deposits of river gravel and the Alluvium are briefly described, and special attention has been given to the soils on the Keuper Marl, Lias, and Drift.

III.—Geological Map of Scotland. By Sir Archibald Geikie, K.C.B., D.C.L., Pres.R.S. Scale 10 miles to an inch. Second edition, with Explanatory Notes. pp. 31. Edinburgh: John Bartholomew & Co., 1910. Price 7*s*. 6*d*. net.

EIGHTEEN years have elapsed since we called attention to the first edition of this map (Geol. Mag., November, 1892); and we now welcome a revised edition, which embodies the later published work of the Geological Survey. The divisions shown in the Index of Colours are practically the same, the Lower Silurian being now taken to include Arenig as well as Caradoc and Llandeilo; while the Old Red Sandstone, subdivided as before into Upper and Lower, has two colours for the lower strata, those north and those south of the Grampians. The principal changes in the map are in the Isle of Arran, where Trias replaces much area formerly coloured as Old Red Sandstone, in the details of Islay, Colonsay, and Gigha, in the country between Oban and Inverary, Rannock Moor, and Blair Athole, and on the borders of Sutherland and Caithness. A considerable amount of geological detail and much topographical information are shown with great clearness on the map. The accompanying explanatory notes have been amplified, more especially with regard to the Volcanic rocks, the Dalradian schists, the Downtonian, and the Old Red Sandstone.

REPORTS AND PROCEEDINGS.

Geological Society of London: Annual General Meeting.

I. *February* 18, 1910.—Professor W. J. Sollas, LL.D., Sc.D., 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. It was stated that the number of Fellows elected during the past year was 64 (as compared with 52 in 1908). Of these, 40 paid their Admission Fees before the end of the year, making, with 15 previously elected Fellows, a total accession of 55 in the course of 1909. The losses by death, resignation, and removal amounted to 44 (3 less than in 1908), the actual increase in the number of Fellows being, therefore, 11 (as compared with an increase of 5 in 1908). The total number of Fellows on December 31, 1909, was 1294.

The Balance Sheet for that year showed receipts to the amount of £3089 8*s.* 4*d.* (excluding £2000, the amount of the Sorby and Hudleston Bequests, and the Balance of £198 0*s.* 2*d.* brought forward from 1908) and an Expenditure of £3125 19*s.* 4*d.*

The Report of the Library and Museum Committee enumerated the extensive additions made during 1909 to the Society's Library, and gave details of the progress accomplished by Mr. C. D. Sherborn in the compilation and arrangement of the great Card Catalogue.

The Reports having been received, the President requested the permission of the Fellows to send a telegram of congratulation to Emeritus Professor E. Suess, F.M.G.S., and, this permission having been granted with acclamation, the following telegram was immediately dispatched to Vienna:—

"Professor E. Suess, Afrikanergasse, 9 Wien, II. The Geological Society, assembled at its Annual Meeting, sends greeting, and offers its congratulations to the veteran author of *Das Antlitz der Erde* on the completion of his great work.—Sollas, President."

The President then handed the Wollaston Medal, awarded to Professor William Berryman Scott, F.G.S., to the American Ambassador for transmission to the recipient, addressing the Ambassador as follows:—

Mr. Whitelaw Reid,—The Council of the Geological Society has awarded the Wollaston Medal, the highest honour which it can confer, to Professor William B. Scott, in recognition of his distinguished services to Geology, especially by his brilliant researches into the Mammalia of the Tertiary Era.

It is now many years since Professor Scott learnt from our famous masters, Huxley and Gegenbaur, all that the old world had to teach touching the comparative anatomy of the Vertebrata. Since then, by his admirable researches on the extinct mammals of both North and South America, he has helped to bring the New World into equal authority with the Old.

More than a quarter of a century ago he undertook, in company with his friend Professor Osborn, those exploratory expeditions into the West of the United States which succeeded in exhuming from the Tertiary rocks the debris of successive mammalian faunas, and returned to the museums of the East laden with the spoils of the past. Illumined by his genius, this material has gradually taken form, and now reveals to an admiring world the ancestral history of diverse existing mammals, such as the Camel, the Rhinoceros, and the Dog.

More recently he organized an expedition into Patagonia, which, during three years of activity, proved equally fertile in results. These are now being set forth in a series of exhaustive monographs, to which Professor Scott has already contributed a masterly account of the genealogy of the Rodents and of the Edentata.

In his comprehensive grasp of the manifold relations which unite the great complex of the animal world, and by his philosophic conceptions of the course of organic evolution, Professor Scott ranks among the select few whom the future will number among the great palæontologists of the illustrious past.

In asking you to receive this Medal for him, I beg you to assure him of the deep interest with which the Society follows his investigations, and to express the hope that he may live long to enrich our Science with discoveries no less important than those which we now celebrate.

The Hon. Whitelaw Reid replied in the following words:—

Mr. President,—I have much pleasure in appearing before this learned body, on behalf of my distinguished countryman, Professor Scott, to receive this Medal for him and in his name.

I may venture also to assure you of his warm thanks, and of the high appreciation with which the great honour that you have thus conferred—the greatest within your gift—will be regarded by Professor Scott himself, and by the noted and very important institution with which he is connected—Princeton University, or 'Old Nassau', as its *alumni* love to call it.

You have enhanced this honour by the cordial and gracious language in which you have been pleased to extend it. It is enhanced also by what I may perhaps call its family origin. We all know too well how family disputes are apt to be the worst and sometimes the most dangerous. Just so, no recognition of success is so sweet as that from the circle of kindred. A generous tribute like this, from the authoritative body of geologists in one branch of the great English-speaking family, for good work done by a leader in that important science in another branch of the same family, is peculiarly grateful to the recipient himself, and grateful also, as well as helpful and inspiring, to his University, to his friends, and in general to his countrymen.

The President then handed the Murchison Medal, awarded to Professor Arthur Philemon Coleman, to the Right Hon. Lord Strathcona and Mount Royal, G.C.M.G., High Commissioner for the Dominion of Canada, for transmission to the recipient, addressing him as follows:—

Lord Strathcona,—The Murchison Medal is awarded to Professor Coleman in recognition of his important contributions to geological science.

During his long and distinguished occupation of the Chair of Geology in the University of Toronto, he has added largely to our knowledge of the history and formation both of the stratified systems and of the igneous rocks of Canada; nor has he restricted his attention to these, but has thrown much light on the origin of some of its most interesting scenery. He has travelled far and wide, and, bringing to bear the vast stores of information gathered in his journeys through North America, Europe, and Africa, he has increased the value of his researches by making use of the comparative method. The deposits of nickel ore at Sudbury have yielded to his investigations conclusions of fundamental importance, which have been recognized and enforced by the veteran author of *Das Antlitz der Erde*. No less important are the results of his researches on the Pleistocene Series in the vicinity of Toronto. His latest achievement—the discovery of glacial deposits in the Lower Huronian rocks of Canada—extends the evidence of uniformity into the remote past of the Protæon.

I had many opportunities of admiring the enthusiasm and energy of Professor Coleman, when we were fellow-hammerers on the Dwyka Conglomerate, and it is with peculiar pleasure that I hand you this Medal, which I beg you to be good enough to transmit to him.

Lord Strathcona said—

that he was greatly honoured and pleased to be the medium of transmitting the Medal to Professor Coleman, on whose behalf he ventured to express his warmest thanks. He added that this was not the first occasion on which he had acted as interpreter to the Canadian branch of the great English-speaking family of the high esteem in which the old Motherland held the brilliant work accomplished by Canadian geologists.

The President then presented the Lyell Medal to Dr. Arthur Vaughan, B.A., addressing him in the following words:—

Dr. Vaughan,—The Lyell Medal is awarded to you in recognition of your distinguished services to Geology, especially in establishing the order of the Faunal Succession in the Lower Carboniferous rocks of Britain.

In your earlier studies of the Jurassic zones with their teeming fossils, you acquired a mastery over the investigation of the known which enabled you to venture with confidence into unexplored regions. Thanks to your researches, the Avon Gorge, once famous for its beauty, has now become no less famous as a scale of geological time.

From all sides—Wales, Ireland, France, Belgium, Germany, and remote parts of Britain—geologists, attracted by this long-desired means of correlation, have hastened on pilgrimage to Clifton, where, under your illuminating teaching, they have been made familiar with all the mysteries of the new standard of reference.

How fortunate have been the results the pages of our Journal bear witness; our knowledge of the stratified crust has been enriched by a whole chapter, and the method of William Smith has once more achieved a triumph.

Of your power to instruct I speak with experience, for I was your pupil when last I visited the Avon section; this recollection adds to the pleasure with which, in the name of the Council, I hand you this award.

Dr. Vaughan replied as follows:—

Mr. President,—Nothing could have given me greater delight, or have come at a more opportune moment, than the news of the award to me of the Lyell Medal.

With the zeal for fresh labours partly dulled by a long illness, this eagerly desired prize came as a welcome spur, restoring self-confidence by assuring me of the sympathy of brother geologists. As yet, sir, I can only hope that, some day, I may have done more to deserve this great honour and the kind words with which you have so generously accompanied its bestowal.

My thanks are rendered heartily and, in very truth, humbly to the Council of the Geological Society and to the many Fellows who have so kindly approved of their selection. I cannot allow this unique opportunity to slip of acknowledging how much my work owes to the inspiring advocacy of two staunch and long-time friends, Professor S. H. Reynolds and Mr. E. E. L. Dixon.

In presenting the Balance of the Proceeds of the Wollaston Donation Fund to Mr. Edward Battersby Bailey, B.A., the President addressed him in the following words:—

Mr. Bailey,—The Balance of the Proceeds of the Wollaston Donation Fund has been awarded to you by the Council in recognition of the value of your investigations into the Carboniferous System of Scotland and the structure of the Glen Coe area. After carrying out successful investigations on the geology of East Lothian, especially in relation to the Glacial phenomena, the volcanic rocks, and the Coal-measures of that district, you, in your paper written conjointly with Mr. C. T. Clough and Mr. H. B. Maufe on the Caldron Subsidence of Glen Coe, analysed with great skill a structure of remarkable complexity, and succeeded in tracing the successive stages of its formation, thus obtaining results which have an important bearing on some of the obscurer problems of volcanic and tectonic phenomena.

The Society hopes that your powers of exact observation and imaginative insight may be exercised with equal success upon the new and difficult problems which again confront you in the West of Scotland.

The President then handed to Mr. John Walker Stather, F.G.S., the Balance of the Proceeds of the Murchison Geological Fund, addressing him as follows:—

Mr. Stather,—The Balance of the Proceeds of the Murchison Geological Fund has been awarded to you by the Council in recognition of the services that you have rendered to Geology, as well by fostering a love of research among your fellow-citizens in Hull as by your own investigations among the Glacial Deposits of East Yorkshire.

For almost a quarter of a century you have furnished inspiration to an active band of fellow-workers, who have worthily maintained the traditions of East Yorkshire as a centre of geological study.

To your own investigations we owe a deeper insight into the intricacies of the latest Glacial Deposits; we have learnt to discern in them successive horizons, each distinguished by characteristic boulders derived from different remote localities; we are able to trace their extension, beyond the limits once assigned to them, even on to the high Chalk Wolds; and we have gained an acquaintance in detail with the drifts of Kirmington and Beilsbeck, which possess so great an interest on account of their included fossils.

May you long continue to exercise that wisely directed energy which has enabled you, in the scanty leisure of a busy life, to achieve so much for our science.

In presenting one moiety of the Balance of the Proceeds of the Lyell Geological Fund to Mr. Frederick Richard Cowper Reed, M.A., the President addressed him in the following words:—

Mr. Reed,—A moiety of the Balance of the Proceeds of the Lyell Geological Fund has been awarded to you by the Council, in acknowledgment of the services that you have rendered to Geology and Palæontology, especially by your researches among the Invertebrate Fossils of Great Britain and Ireland, Africa, and India.

Since the publication of your first paper in 1892, memoirs and monographs have proceeded from your pen in an unremitting stream. Amidst work so various and voluminous, it is difficult, where all is good, to know what to select for special praise; but all will acknowledge, as enduring monuments of painstaking industry and exact research, your monographs on the Trilobites of Girvan, the Fauna of the Bokkeveld Beds, the Fossils of the Northern Shan States, and the Cambrian Fossils of Spiti.

To numerous colleagues in the field you have brought the indispensable aid of Palæontology. They will join in welcoming this award, and in expressing with me our best wishes for your continued success in the work of investigation.

The President then handed the other moiety of the Balance of the Proceeds of the Lyell Geological Fund, awarded to Professor Robert Broom, M.D., to Dr. A. Smith Woodward, Sec. G.S., for transmission to the recipient, addressing him as follows:—

Dr. Smith Woodward,—The Council of the Geological Society have awarded a moiety of the Balance of the Lyell Geological Fund to Professor Robert Broom, in recognition of his work on the Fossil Reptiles of the Karoo.

While practising medicine in New South Wales, Professor Broom found time to make researches into the anatomy of the Monotremes and Marsupials; these led him to reflections on the origin of the Mammalia, and, in the hope of obtaining a solution of this question, he left Australia for Cape Colony, settling in a district where, while still engaged in the practice of his profession, he could collect and study the reptilian remains of the Karoo. He has since been able to devote himself almost entirely to this pursuit, and has published a long series of memoirs which add largely to our knowledge of the Fossil Reptilia.

We trust that the Karoo has still many discoveries in store for him, and that he may be destined to throw still further light on the predecessors of the Mammalia.

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 Mr. T. Mellard Reade (elected a Fellow in 1872); Mr. J. E. Saunders (el. 1855); Dr. J. Whiteaves (el. 1859); Mr. H. Bauerman (el. 1863); the Marquess of Ripon (el. 1867); Mr. F. G. Hilton Price (el. 1872); Mr. H. M. Klaassen (el. 1877); Mr. W. F. Stanley (el. 1884); Mr. James Parsons (el. 1900); and Mr. E. Kelly (el. 1875).

He then dealt with the Evolution of Man in the light of Recent Investigations. Considering first the human remains of the Pleistocene Epoch, he pointed out that, so far as the evidence extends, it shows that the cranial capacity of the human skull increases rather than decreases as we pass backwards in time. The oldest known human skulls are later than the Chalky Boulder-clay. The cranial capacity is merely a morphological character of unknown significance. Observation shows that no discoverable connexion exists between it and the intellectual power.

The most recent researches in comparative anatomy emphasize the close connexion between Man and the Anthropoid Apes, especially the Gorilla and the Chimpanzee. A similar result is afforded by the investigations of Uhlenhuth and Nuttall into blood-relationship.

All recent researches converge to show that the genealogy of Man is to be traced through the Anthropoid Apes and the Catarrhine Monkeys to the Lemurs. Cope's suggestion of a direct descent from extinct Lemurs receives no confirmation. Primitive characters, when present in Man, can be better explained by regression and adaptation.

Man probably diverged from the phylum of the Primates above the point of origin of the Gibbon, and not far from that of the Gorilla and the Chimpanzee. He owed his progress in the first place to emancipation from a forest life, and commenced his career as the ape of the plains. The erect attitude and the use of the hand as a universal instrument followed as a consequence. Ancestral Man was probably a social animal at a very early period, and social life afforded a stimulus to the development of the powers of speech. He was probably distinguished by great bodily strength and by the possession of formidable natural weapons of defence and offence. With the invention of weapons made by art the necessity for natural weapons disappeared, and a regressive development of the teeth with adaptation to purely alimentary functions commenced. A purely human dentition characterizes the Heidelberg jaw, which is the oldest known. This, however, still reveals in all other respects strong simian affinities.

The growth of the brain in size and complexity might be correlated with the evolution and use of the hand, but to a far greater extent with the development of the powers of speech and the consequent exchange, multiplication, and co-ordination of ideas.

The Ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—Council: Tempest Anderson, M.D., D.Sc.; Charles William Andrews, B.A., D.Sc., F.R.S.; George Barrow; Professor William S. Boulton, B.Sc.; James Vincent Elsden, B.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.; Finley L. Kitchin, M.A., Ph.D.; Bedford McNeill, Assoc.R.S.M.; John Edward Marr, Sc.D., F.R.S.; Horace W. Monckton, Treas.L.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.; Henry Woods, M.A.; Arthur Smith Woodward, LL.D., F.R.S., F.L.S.; Horace Bolingbroke Woodward, F.R.S.; and George William Young.

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

The following communication was read:—

"Metamorphism around the Ross of Mull Granite."[1] By Thomas Owen Bosworth, B.A., B.Sc., F.G.S.

The Ross of Mull granite is a coarsely crystalline plutonic mass, forming the western portion of the Ross of Mull and extending over some 20 square miles.

The intrusion is conspicuously later than the Moine rocks, and is regarded as one of the 'newer granites'. The rock shows very little evidence of faulting or movement of any kind, and is traversed by sheets of mica-trap. The eastern boundary of the granite is a very intricate line of junction with typical Moine Schists and Gneisses, into which it has been intruded. Injection-breccias occur along the margin, where the granite is crowded with schist-inclusions.

The changes in the pelitic schists are of two kinds, and are considered under separate headings (*a*) and (*b*) below.

(*a*) *Impregnation.*—The schists have been impregnated with the granite in a very intimate manner—(1) along irregular cracks, (2) along bedding-planes, (3) along strain-slip, and (4) along foliation.

Variously banded rocks have been thus produced, which suggest how readily these processes, carried out on a large scale, would convert pelitic sediments from the state of schists into crystalline igneous gneisses.

(*b*) *Thermal Metamorphism.*—In some places the pelitic gneiss in contact with the granite, and commonly the masses included in the granite, have been very highly altered. The new minerals formed are sillimanite, andalusite, cordierite, and green spinel; and these are present in such amount that their formation must have been accompanied by much recrystallization among the quartz, felspar, and mica also.

Sillimanite is the most abundant new mineral, and occurs not only as fibrolite throughout the rock, but also in larger crystals which are often grouped together in prismatic aggregates. These aggregates weather out as conspicuous knobs, measuring about an inch across.

Under the microscope, the sillimanite is seen to enclose large numbers of grains of green spinel. The cross-sections of sillimanite are diamond-shaped, and show a pinacoidal cleavage; their colour

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

between crossed nicols is a very low grey, and good interference-figures are obtained.

The association of minerals in the schists is the same as that noticed at the margin of the Ben Cruachan 'newer granite' mass, and also at the margin of 'newer granite' at Netherly in Elgin.

Tourmaline, kyanite, and staurolite also occur in the Moine Schists of Mull, but are in no way connected with the granite.

CORRESPONDENCE.

CAPE COLONY.

SIR,—In the review of the work by Dr. Rogers and Mr. Du Toit (GEOL. MAG., December, 1909, p. 561) attention was called to the absence of references to authorities *in the index*, not in the text.

REVIEWER.

March 17, 1910.

THE MEANING OF THE TERM 'LATERITE'.

SIR,—In discussing the meaning of the term 'laterite', I have at least the qualification of an intimate acquaintance with the material to which the name was first given in the area in which it is typically developed.

As I understand Mr. Scrivenor, he contends that whatever may have been its original signification, it has been so widely employed in other senses that it should be dismissed from scientific language, the more so as the word 'bauxite' is available to replace it.

It must be remembered, however, that bauxite is a mineral name indicating a substance containing approximately two molecules of water to one of alumina, whatever may be its true chemical constitution. The bauxite of the type locality, Baux near Arles in the south of France, is believed to have resulted from the action of aluminium sulphate on limestone, but this is only one way in which such a product might have been formed.

Laterite, on the other hand, is a rock name given to a widespread clay-like deposit which plays a conspicuous part in the surface features of Peninsular India. It has recently been recognized with similar characters in other tropical countries, and has been shown by the classical researches of Max Bauer, Warth, and Holland to be formed by the surface decomposition of alumina-bearing crystalline rocks, whereby the alkalies, alkaline earths, and combined silica are to a large extent removed, leaving behind the free silica, the titanium oxide, and the oxides of alumina and iron, which have taken up water to form hydrates.

This well-characterized formation obviously requires a special designation, and what could be more suitable than the name that Buchanan applied to it over a century ago, and which is still employed in the Peninsula in the same sense in scientific, technical, and popular language. Mr. Scrivenor appeals to the usage of engineers, but to the best of my recollection I never heard the term applied to any other material by a South Indian engineer during my four years' residence in the State of Mysore.

Curiously enough, at the date of the publication of the second edition of the Manual of the Geology of India in 1893, no complete analysis of laterite from the Peninsula of India was known, and its characteristic chemical composition was still unrecognized. Since that date numerous analyses of laterites from widely distant tropical localities have been made. The most recent information on the subject may be obtained from a second paper by Max Bauer (*Neues Jahrb. für Min.*, etc., Festband, 1907, pp. 33–90), a report from the Imperial Institute on specimens from the Balaghat District of the Central Provinces of India (Rec. Geol. Surv. Ind., 1908, vol. xxxvii, pp. 213–20; Bull. Imp. Inst., 1909, vol. vii, pp. 278–85), both of which contain full information on previous literature and analyses, and an interesting contribution by J. Chantard & P. Lemoine (*Comptes Rendus Acad. Sci.*, vol. cxlvi, pp. 239–42; *Bull. Soc. de l'Indust. Min. St. Étienne*, 1909, ser. IV, vol. ix, pp. 1–37), in which are traced out the changes that have taken place in the formation of laterite on the assumption that the amount of titanium oxide has remained unaltered.

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*; and if, as sometimes happens, the aluminium hydrate is in course of time washed away, an accumulation of scoriaceous iron ore may be left behind which is certainly not laterite, though it may be derived from it. It is probably this which has given rise to the misuse of the term for surface iron ore, which is common in some of our colonies.

It would be difficult to conceive a stronger case for the application of the rule of priority than the present. The term laterite was applied as early as 1807 to a well-marked rock type, and has continued in use ever since with the same signification, which has been adopted by writers on tropical geology in Germany and France, and received the endorsement of authorities like Keyser (*Lehrbuch*, 1909, vol. i, pp. 282–3). At the same time it has met with general acceptance in this country. Yet we are told that it must be abandoned because it has been wrongly employed by Colonial engineers who are unacquainted with the material to which it is properly applied.

John W. Evans.

Imperial Institute, S.W.

OBITUARY.

HENDERICUS M. KLAASSEN, F.G.S.

Born 1828. Died January 22, 1910.

We regret to record the death at Croydon, in his 81st year, of Mr. H. M. Klaassen. He was born at Kritzum in Hanover, where his father was the minister of the Dutch Reformed Church. After the ordinary school education in his native town he was trained for business, and in his twentieth year he came to England, and having gained experience he started on his own account as a seed factor on the London Corn Exchange in Mark Lane. The undertaking was successful, so that he was enabled to retire from business in 1874. He then followed his natural bent toward science, and attended the courses of lectures on Chemistry, Zoology, and Geology at University College, London. His predilection for this last-named science was greatly stimulated by John Morris, at that time Professor of Geology at the College, and he was induced to join the Geologists' Association in 1875, and was elected a Fellow of the Geological Society in 1877.

In 1883 Mr. Klaassen contributed a paper, "On a Section of the Lower London Tertiaries at Park Hill, Croydon," to the Proceedings of the Geologists' Association, in which a detailed description was given of the character of the beds and their fossils exposed in a deep cutting on the Woodside and South Croydon Railway. During the eighteen months the cutting was in progress Mr. Klaassen visited the work regularly every day, and thus secured a complete record of the beds exposed, and moreover he discovered some fossil bones which were described by Mr. E. T. Newton, F.R.S., as in part belonging to a new species of mammal which was named *Coryphodon Croydonensis*, and in part to a gigantic species of bird, larger than an ostrich, which received the name of *Gastornis Klaasseni* [1] in honour of its discoverer.

A second paper by Mr. Klaassen, "On the Pebbly and Sandy Beds overlying the Woolwich and Reading Series on and near the Addington Hills, Surrey," was contributed to the Proc. Geol. Assoc. in 1890.

Mr. Klaassen was an earnest supporter of the Croydon Natural History and Microscopical Club, and he took a prominent part in founding a school in Croydon for the secondary education of girls in connexion with the Girls' Public Day School Company. Endowed with a genial temperament and sound judgment he won the regard of numerous friends, by whom his memory will be kindly cherished.

ROBERT MARCUS GUNN, M.A., F.R.C.S., F.G.S.

Born 1850 (? 1851). Died December 2, 1909.

Mr. Gunn, who was a distinguished ophthalmic surgeon, had devoted his leisure during many years to the collection and study of fossils. Born at Dunnet, in Caithness, he belonged to the Clan Gunn, and was son of Marcus Gunn of Culgower, on the eastern coast of Sutherland.

[1] See E. T. Newton, "On a Gigantic Bird from the Lower Eocene of Croydon, *Gastornis Klaasseni*, Newton": Proc. Zool. Soc., May 5, 1885, and Geol. Mag., 1885, p. 362.

In the reefs and low cliffs of Upper Jurassic rocks, near Culgower, many plant-remains occur; and these, together with other specimens obtained near Brora, were assiduously collected by Mr. Gunn, who had hoped to prepare a memoir, in conjunction with Professor A. C. Seward, on the fossil flora of that district. His valuable collection of Brora Jurassic plants had been given by Mr. Gunn, just before his death, to the Geological Department of the Natural History Branch of the British Museum. Mr. Gunn also obtained from the Old Red Sandstone of Achnarras, Caithness, a supposed fossil Marsipobranch fish, described by Dr. Traquair under the name of *Palæospondylus Gunni.* A restoration of the remains was given in the Geological Magazine for 1893, p. 471.

Mr. Gunn had become a Fellow of the Geological Society in 1908, and his death causes a sad gap in the ranks of enthusiastic amateur workers.

H. B. W.

MISCELLANEOUS.

The Darwinian Theory.

The Darwin Centenary, to the commemoration of which we called attention in August last (Geol. Mag., 1909, p. 375), naturally led to the choice of topic in several presidential addresses delivered during the same year.

This was the case in Dr. D. H. Scott's address last year to the Linnæan Society. He pointed to the evidence that at all known stages of the past history of plants there has been efficient adaptation to the conditions; and natural selection appears to afford the only key to evolution. The palæontological record reveals a relatively short section of the evolution of plants, and indicates that while there has been considerable change, there has not been, on the whole, any very marked advance in organization, except in such cases as the floral adaptations of Angiosperms. The simple forms of plants existing at the present day are, as a rule, of a reduced rather than a primitive nature, and yet they may have a considerable degree of antiquity.

Mr. B. B. Woodward dealt with Darwinism and Malacology in his address to the Malacological Society, 1909. He remarked that the Mollusca probably furnish the best means of tracing out the workings of evolution, as the shell, properly dissected, will yield evidence of the life-history of the animal. The nature of the changes in form during the growth of species of Cephalopods and Gasteropods was discussed and explained; and we are led to understand how it is necessary sometimes to break up an Ammonite before the species can be definitely determined. The address embodies the results of the latest researches on the subject.

Quite recently, in commemoration of the Jubilee of the Liverpool Geological Society, a meeting was held on January 11 at the Royal Institution, Liverpool, when Professor J. W. Judd delivered a lecture on "The Triumph of Evolution", justifying the selection of the topic by remarking that the foundation of the Society was coincident with the appearance of Darwin's *Origin of Species.*

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MAY, 1910.

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THE

GEOLOGICAL MAGAZINE.

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No. V.—MAY, 1910.

ORIGINAL ARTICLES.

I.—Relics of the Great Ice Age in the Plains of Northern India.[1]

By T. H. D. La Touche, Geological Survey of India.

It may seem strange to dwellers in this country under its present conditions to speak of relics of a Glacial Period being visible in the plains of the Ganges Valley, where the mean annual average temperature is about 77° F. and we all know what the maximum may rise to; and at the outset I must guard against misapprehension by saying that I do not mean to imply, by the title of my discourse, that the plains of India were ever, within geologically recent times, covered with snow and ice. We have evidence, it is true, that in long distant ages, at the beginning of the period that saw the filling up of the valleys of the old Gondwana continent, part of which still exists as the Peninsula of India, that is to say, when the deposits of clay and sandstone, supporting a luxuriant vegetation, now transformed into the coal of Raniganj and other localities, were beginning to be laid down, the higher ground of the Peninsula was under snow and ice, and that glaciers descended into the low ground and probably sent off icebergs into the surrounding seas. Traces of these events, which took place in what is known to geologists as the Talchir Period, even the old rock-floors grooved and striated by the passage over them of fragments of rock embedded in moving ice, have been found at the base of the Coal-measures in the Central Provinces and in Rajputana, while a bed containing striated and polished boulders, exhibiting unmistakable evidence of ice action, is known in the Salt Range of the Punjab. But with these, and with traces of what may prove to have been a still older ice age, of which Sir T. Holland brought some evidence before this Society in August, 1908, discovered by him near Simla, I do not propose to deal on the present occasion.

The period of a general lowering of temperature over the northern hemisphere, to which the name of the Glacial Period *par excellence*, or of the "Great Ice Age", has been given, has left abundant traces of its passage over the whole of that hemisphere, wherever the conditions are favourable for the preservation of the peculiar features which denote the action of large bodies of ice. Naturally these features are

[1] A lecture delivered in the rooms of the Asiatic Society of Bengal, Calcutta, on February 10, 1910.

prominent in proportion to the accumulation of ice that took place in any given region. Thus they are clearly visible in all the countries surrounding the Pole, especially so in North America, the British Isles, Scandinavia, and Siberia, where there has been found conclusive evidence to show that, during the period of maximum glaciation, a huge ice-cap buried a very large part of those countries, and in England extended as far south as the Thames Valley. This evidence is rendered more conclusive by the fact that, strictly speaking, the last Glacial Period has not yet come to an end, but that its peculiar characters still persist within the Arctic Circle, and we are therefore able to follow the indications of its passage step by step, from the edge of the great ice-sheet that even now covers the greater part of Greenland and the extreme north of the American continent, southwards across the plains of Canada or the hills of Scotland, until we come upon indubitable signs of what was once the outer edge of the larger ice-sheet of the past.

But the Arctic Circle is not the only region that affords evidence of the persistence into our present humdrum times of the last Glacial Period. Every range of mountains that raises its crest to a sufficient elevation above the sea-level, provided that there is also a sufficient precipitation of moisture, is, as there is no need for me to point out to those of you who have seen the Himalaya, covered with so-called permanent snow and ice, the lower limit of which rises gradually from the sea-level as we recede from the Pole. And in each of these ranges there is equally indubitable evidence, indications of which may be followed down from the still ice-bound crests, through the valleys, of an extension of the ice and snow to much lower altitudes within quite recent times, considered from a geological point of view; so recent that it is quite certain that man, the most highly developed being on the earth, had already appeared and attained to some degree of culture while that period of intense cold was in progress.

It is not my intention to enter now into a discussion of the causes of the Glacial Period, or of the phenomena that marked its passage, except in so far as the latter affect this country. As Sir Archibald Geikie says in his *Text Book of Geology*,[1] "No section of geological history now possesses a more voluminous literature than the Glacial Period," and to give you even the slightest idea of the theories that have been put forward to account for it would lead me far beyond the limits allowable for a single lecture. Even now geologists and other scientific men are not in agreement as to the true cause of this widespread refrigeration of climate, and I must only ask you to accept the assertion that it did take place, though I may say that in case you are not disposed to do so, and prefer to attribute the phenomena I am about to describe to a general inundation, such as Noah's flood, or some similar catastrophe called by another name, you will find yourselves in very good company, even in scientific circles.

In bringing forward evidence which, in my opinion, shows that relics of this Glacial Period are still to be found in the plains of India, it will perhaps be best to follow the same line of inquiry that

[1] 4th ed., vol. p. 1301, note.

I indicated in speaking of the great ice-sheet, and start with those regions where glacial conditions still prevail, the highest ranges of the Himalaya, that is to say, and see what are the peculiar physical features that accompany a lowering of the temperature. The first of these is a former extension of the glaciers far beyond their present limits. As a glacier moves it carries on its surface or embedded in the ice huge accumulations of loose material fallen from the hill-sides rising above it, and at its snout, where the ice melts, deposits this material in an embankment-like heap, known as its terminal moraine, just as a gang of coolies builds up a railway embankment. If then the glacier retreats, this embankment will be left behind as a sign of the former extension of the ice. In many of the Himalayan valleys remains of these ancient moraines have been found as low down as 7000 feet, whereas the present limit of the glaciers varies from 11,000 to 13,000 feet. General McMahon records the existence of an old moraine near Dalhousie, in the North-West Himalaya, at an elevation of about 4740 feet above the sea.[1]

But these ancient moraines are not the only indication that the glaciers were at one time of far greater size. In some cases smoothed and scratched surfaces of rock on the valley sides, far above the present level of the ice, bear witness to its former depth. The striking contrast between the U shape of a valley which has once been occupied by a glacier, and the V shape of the valley below, so characteristic of the inner Himalaya, even where old moraines are absent, affords further proof in the same direction.

But, as I remarked before, we have no evidence that any of these glaciers ever descended as low as the plains of India, though an enthusiastic glaciologist, Mr. Theobald, once a member of the Geological Survey, thought that he had obtained such evidence in Kumaon, in the shape of old moraines, and on the plains of the Potwar, an elevated tract of country lying north of the Salt Range, between the Jhelum and the Indus.[2] We must look for the evidence which I now wish to place before you in another direction.

One of the most striking features of the tracts that lie in the immediate neighbourhood of the snows is the absence of vegetation. Although those who have done no more than make a trip to one of the more accessible glaciers may be charmed by the sight of forests of pines or birches flourishing in close proximity to the ice, and with the grassy sward clothed with flowers that cover even the moraines, a climb of a few thousand feet will bring them to a region where not even a blade of grass is to be found, and the only vegetation met with consists of mosses, lichens, and a few of the most hardy flowering plants. One result of the absence of vegetation is that the agents of disintegration of the rocks have full play. The constant fluctuations of temperature, for even at these altitudes the sun by day has great power, the alternate freezing and melting of water in the pores and interstices of the rocks, the violence of the wind, and the almost constant precipitation of moisture, all combine in

[1] Records, Geol. Surv. Ind., vol. xv, p. 49.

[2] Ibid., vol. vii, p. 86; vol. x, pp. 140, 223; vol. xiii, p. 221. See also A. B. Wynne, ibid., vol. xi, p. 150; vol. xiv, p. 153.

rotting away, if I may so express myself, and breaking up the rocks with great rapidity, in comparison with tracts where the roots of grass and trees hold together and form a protective covering of soil. At these altitudes many of even the highest peaks are almost buried under an accumulation of their own debris, so much so that it is sometimes possible to ascend to heights of 20,000 feet or so with no more discomfort than is caused by the difficulty of breathing in a rarified atmosphere. This loose material is always in a state of more or less unstable equilibrium, and when lying on steep hill-slopes is constantly liable to be precipitated into the valleys, especially when it is saturated with moisture by melting snow or rain. When this happens in a tributary valley, the semi-liquid mass moves irresistibly downwards as an avalanche of mud mingled with boulders and fragments of rock, and on reaching the valley of the main stream or river, spreads itself out as a conical fan, radiating from the mouth of the tributary. In all the valleys of the higher Himalaya these fans can be seen in actual process of formation, and they may sometimes be met with even at elevations well below the snow-line, when the head of the tributary stream reaches up to a sufficiently high altitude. When the side-streams are close together the fans often coalesce, forming a more or less continuous terrace along the banks of the main river.

If we now follow the larger valleys downwards, we find that, when we reach altitudes of say 7000 feet or less, exactly similar cones or fans occur along each bank wherever the main stream is joined by a tributary, but that these fans bear every sign of great antiquity, in proportion to their distance from the snows. Not only are they covered by vegetation and usually cultivated, but they are often selected as sites for villages, on account probably of the ease with which water can be obtained by leading channels from the side-stream. (I have also noticed this propensity in the Alps, where in the main valleys each fan will have its well-watered little town built upon it.) This shows that no fresh material has been spread over the fans within recent times. Moreover, the stream that originally formed them, instead of flowing in devious rivulets over their surface as it did at first, has now cut a single deep channel directly through the centre, so profound in most cases that it is evident that a very long time has elapsed since the stream ceased to construct the fans. Lower down still the whole of the valley is found to be choked with a great thickness, often as much as three or four hundred feet, of loose deposits continuous with and similar to those forming the cones, out of which the river has cut great terraces, now on one side and now on the other, with a perpendicular face towards the river. Sometimes only small remnants of these terraces are now left, but at other times they form large level plateaus, on which considerable towns may be built.

The origin of these terraces has aroused some discussion among geologists, for it is evident that they are now being washed away by the rivers that once deposited them, and that, being high above the present flood-level, there must have been a great change of conditions of some kind since that time. Changes of level, either resulting from a recent elevation of the mountains or a depression of the plains, causing an increased fall, and consequently higher velocity and greater erosive power in the rivers, have been evoked in order to account for the facts; but a visit to any of the valleys will show that the loose material of the terrace cliffs *extends in most cases down to the present water-level,* and it is evident therefore that the existing valleys *must have been excavated to their present depth* before the terraces were deposited in them. In other words, that the configuration of mountain and valley was much the same before the terrace-forming period as it is now, and that since that period the rivers have been able to do little more than clear out their old channels. There may have been some elevation of the inner Himalaya during the course of these events, but the diminution of the burden thrown into the rivers, due, as we have seen, to the reclothing of the hills with vegetation on the retreat of the ice, is quite sufficient, I think, to account by itself for the change from deposition to erosion. A depression in the Indo-Gangetic Valley, which by increasing the gradient would also increase the erosive power of the rivers, seems equally out of the question; for, as we have seen, the excavation of the river-valleys took place before the terrace-building period, and the material removed from them must have filled up the depression as quickly as it was formed, even if the addition of this weight on the rocky floor below the plains did not actually cause the depression, as some have supposed. In any case, there is nothing to show that during the terrace-building period the hills and plains did not stand in much the same relation to each other as they do now.

Even at the present day it is sometimes possible to find the conditions of the terrace-building reproduced at quite low levels among the hills. Owing to the recent immigration of Nepalese cultivators into Sikkim, the forests that once clothed the hill-sides in that very jungly country have to a great extent been cut down, and the natural consequence is that landslips are very common. One striking instance of this I came across in the valley of the Rangpo, a large tributary of the Teesta north of Kalimpong. The forest on the north bank of this river has been almost entirely cleared off, and owing to the steepness of the hill-slopes and to some peculiarity in the lie of the rocks, an almost continuous line of landslips, extending for several miles, has taken place. These have thrown an enormous quantity of debris into the river, which is unable to carry it away at once, and the bed of the river is thus being rapidly raised, the water flowing in numerous channels over the surface of the deposits. If now the forest were to grow up again and the landslips cease, the supply of material would come to an end, and the river would at once begin to cut for itself a defined channel through the accumulation of loose stuff in its bed, and as it wound from side to side would leave terraces on either bank, and this without our having to imagine any increased velocity in the stream due to increase of gradient.

The terraces I have described are not confined to the valleys of the Himalaya, but are to be found all round the northern limits of the Peninsula, from Assam on the east to Baluchistan on the west. Even in this latter country, now so extremely arid, they attain to large dimensions, much larger than the puny streams of that country could now account for.

In following down the valleys we have seen that the features peculiar to the upper, still glaciated regions are reproduced at the lower levels, but that the causes that led to the production of these features at these lower levels have now passed away. What is more likely to have been the cause of these similar phenomena than a similarity of conditions, that lowering of temperature and consequent increase in the power of the erosive agencies which we call the Glacial Period; one which we know to have occurred in times geologically recent, but long enough ago to account for the erosion that has since taken place?

It remains now to extend the argument to the plains of India, but it is not to be expected that the evidence in this region will be of so convincing a character as that afforded by the Himalayan valleys. There is some direct evidence, it is true, that the plains participated, as was only natural, in the general refrigeration of climate afforded by the fact that a large number of Himalayan plants are found on the higher hills and plateaus of the Peninsula, and that, as I am informed by Dr. Annandale, of the Indian Museum, a small portion of the fauna of Parasnath Hill in Bengal is of a type peculiar to the Himalaya; showing that the temperature of the intervening plains must have been lowered sufficiently, and that for a long enough period, to allow these plants and animals to wander so far to the south. But this evidence is not of the character that I am dealing with at present. Since the ice and snow did not actually descend to the plains, their influence on the deposits of the latter can only have been of a secondary character, and to a great extent these must have been obliterated by the divagations of the great rivers, so that only the merest relics now remain.

Throughout the valley of the Ganges and its tributaries patches of what is known as the 'older alluvium' are to be found, rising to a considerable height, often as much as 100 feet, above the present flood-levels. This alluvium is generally to be distinguished from the later river-silts by its red colour, which has given the name of Rangamati, 'coloured earth,' to so many villages in Bengal and Assam; and by its containing quantities of the peculiar nodular form of limestone known as 'kunkur', the presence of which is in itself a sign that the deposits are of considerable antiquity, for it owes its origin to the slow accretion of particles of carbonate of lime dissolved out of the slightly calcareous sediments by percolating water, and re-deposited in the form of nodules as the water evaporates.

One of the most conspicuous instances of this old alluvium is the elevated tract known as the Madhupur Jungle, extending to the north of Dacca between the present channel of the Brahmaputra and its old course into the Meghna. The soil of this tract is a stiff red clay, evidently an old river-silt, but raised to a height of some 60 to 100 feet above the flood-levels of the rivers on either side. Several other patches occur in the lower Ganges valley, but as we ascend the river and its tributaries into the United Provinces and Bundelkhand, we find that this older alluvium is almost universally distributed, and has a distinctive name, that of 'bhangar' in contrast with the low-lying 'khadar' or straths along the river-courses, and that it bears every sign of being in a state of rapid erosion; that it belongs in effect to a condition of things that has now passed away, when the rivers probably possessed a much greater volume of water and brought down correspondingly greater quantities of silt.

Now we have seen that it is possible, indeed quite certain, that during the Glacial Period exceptionally immense quantities of debris were precipitated into the rivers, more indeed than they were able to carry away comfortably, as the terraces in their upper valleys show. Is it not, then, reasonable to suppose that it was then that the lower valleys of the same rivers were choked with a superabundance of silt, and that to this same period it is that we must attribute the formation of the 'older alluvium'; that, in fact, these deposits are as truly relics of the passage of the Glacial Period as the ancient moraines among the hills?

It is always a source of satisfaction to the geologist, or indeed to any scientific man, when he finds that a theory intended to explain a certain series of facts can be used to clear up difficulties that may surround another series of equally well-ascertained facts. The changes of the courses of the rivers of Lower Bengal have for a long time exercised the minds of surveyors, engineers, and geologists, and various explanations of them have been put forward, especially of the comparatively sudden desertion by the Brahmaputra of its old channel, which ran to the east of Dacca at the beginning of the last century. This problem was first seriously attacked by Mr. Fergusson fifty years ago,[1] and partly turns on the question of the origin of the elevated tract of ground I have already mentioned, the Madhupur Jungle. He attributed it to a special upheaval of that part of the delta which deflected the Brahmaputra into the Meghna and the jheels of Sylhet. But we should have to apply the same reasoning to other patches of the older alluvium, and it is difficult to suppose that each of them is due to a special upheaval; moreover, one would think that an upheaval in that particular place would be more likely to force the Brahmaputra westwards than deflect it to the east. Nor does it account for the fact that the Brahmaputra, now a much larger river than the Ganges, allowed itself to be pushed aside in this way; or that, considering that it brings down very much more silt than the Ganges, it should have done so little towards filling up the Sylhet jheels. But a study of the present river-courses will, I think, throw some further light on the subject.

The Dihang, which it is now universally admitted brings down the waters of the Tsanpo of Tibet into the Brahmaputra, is not, I think, the original main channel of the latter, but was, until quite recent times, a mere tributary. It is only within the last thirty years that it has been proved beyond doubt that the Tsanpo is connected with the Brahmaputra, though Rennell was the first to recognize that it must be so in 1765.[2] Only a few days ago I saw a modern atlas in which the

[1] Quart. Journ. Geol. Soc., vol. xix, p. 330.
[2] *Memoir of a Map of Hindoostan*, London, 1792, 2nd ed., p. 356.

Tsanpo was shown as flowing on eastwards into the Salween. Now it is not at all unlikely that, at the period I have been speaking of, the Tsanpo either flowed westwards, as Burrard and Hayden maintain, and escaped through the Himalaya at some other point,[1] or lost itself in the deserts of Tibet, and that then the Dihang *was* a mere tributary of the Brahmaputra, but that it has since cut back at its head into the valley of the Tsanpo and 'beheaded' it. If this was so, the Brahmaputra must have been a comparatively small river at that time, and it is not surprising that in its lower course it was pushed aside by the alluvium brought down by the Ganges and its tributaries. Indeed, it may be that the Madhupur Jungle is a relic of the old delta face of the Ganges, and that to the east of it, at that time, there was open water, reaching perhaps up to the foot of the Khasi Hills; in this way I would account for the backward state of that part of the delta. But when the Dihang beheaded the Tsanpo, and brought down this enormous accession of water, the Brahmaputra began to assert itself. At first it could do little, for the accumulation of alluvium in its path was too great to be swept away, and it had to be content with its old course into the Meghna; but it had a treacherous ally in the Teesta, which had gradually been sapping the defences of the Ganges. The Teesta, wandering from side to side over the old alluvium south of its exit from the hills, swept it away by degrees, wearing down the face of the country to the west of the Madhupur Jungle, and in course of time opened a passage for the spill-water of the Brahmaputra down the Jennai River. Finally the Teesta, frankly deserting its lawful sovereign, the Ganges, threw itself suddenly (this happened so recently as 1787) into the Brahmaputra. The effect of this was not at first noticeable, but it is probable that the extra silt brought down by the Teesta was too much for the Brahmaputra to deal with, hampered as it was already by the damming back of its waters by the Meghna as the latter slowly raised the levels of Sylhet, and that the two allied rivers were compelled to find a new channel. The insignificant Jennai offered the means of escape, and its bed was occupied about one hundred years ago.

The struggle that then began between the Brahmaputra and the Ganges is still in progress, and issue was joined so recently, almost within the memory of men now living, that we cannot suppose that it has yet been fought to a finish, or that developments may not take place that will have far-reaching effects upon the future history of Bengal. The Brahmaputra, being the more powerful river, is not likely to rest content with the advantage it has already gained. Up to the present time, indeed, it has not been able to exert its full strength, for it cannot do so until it has brought the level of the Assam Valley to the state in which it would have been had the valley been originally excavated by a river of the size and power of the present Brahmaputra. As it is, much of the force of the river when in flood is spent in the low ground flanking its course; but when this has been brought to the true 'regimen', there is no doubt but that the river will be able to show its real strength with more

[1] *Geogr. and Geol. of the Himalaya Mountains*, Calcutta, 1907, pt. iii, p. 155.

effect in its lower course. Even in 1838 it had succeeded in damming back the Ganges to such an extent near the confluence that the latter was fordable at several places above Goalundo, and was compelled to seek for a new exit to the sea. The Garai, which leaves the Ganges at Kushtia, was enlarged from a mere creek unable to float a vessel drawing more than a foot or two of water, as Rennell found it in 1764, to a broad and deep river, now the principal steamer-route from Calcutta to the Upper Ganges. What further developments may take place we cannot predict, but it is possible that their influence may be felt still higher up the Ganges, and may even extend to the Jalangi or the Bhagirathi, and so affect the welfare of Calcutta. The mitigation of any evil effects these changes may have is a matter for the consideration of engineers. If they become acute, something might be done to assist the Ganges by inducing the Teesta to return to its old allegiance; but the forces exerted by such vast bodies of moving water are so prodigious that it is unsafe to speculate without a complete knowledge of the facts.

II.—The Geology of the Dolgelley Gold-belt, North Wales.

By Arthur R. Andrew, M.Sc., F.G.S.

(*Continued from April Number, p.* 171.)

History and Statistics of Gold-mining in the Dolgelley Area.

It is believed that the ancient Britons and the Welsh were fully aware of the precious metal which lay among their hills. Three Welsh chieftains are known to have possessed chariots of gold, and it is inferred that this gold was derived from mines which the Welsh worked at an early date. Many gold ornaments have from time to time been unearthed, and as their style differs entirely from that customary at the early Christian period, they are believed to belong to a time long anterior to that of Christianity. Again, it is known that the Romans under Julius Cæsar worked minerals in various parts of Britain, and there are many evidences of Roman mine-workings where gold must have been the principal, if not the sole, object of search. One of the most remarkable of these is outside Merionethshire, at Gogofau, near Pumpsaint, in Carmarthenshire, where the traces of Roman occupancy are undoubted. Another locality, this time in Merionethshire, is reported by Ramsay (12, p. 64) as on the banks of the Allt-y-Wenallt.

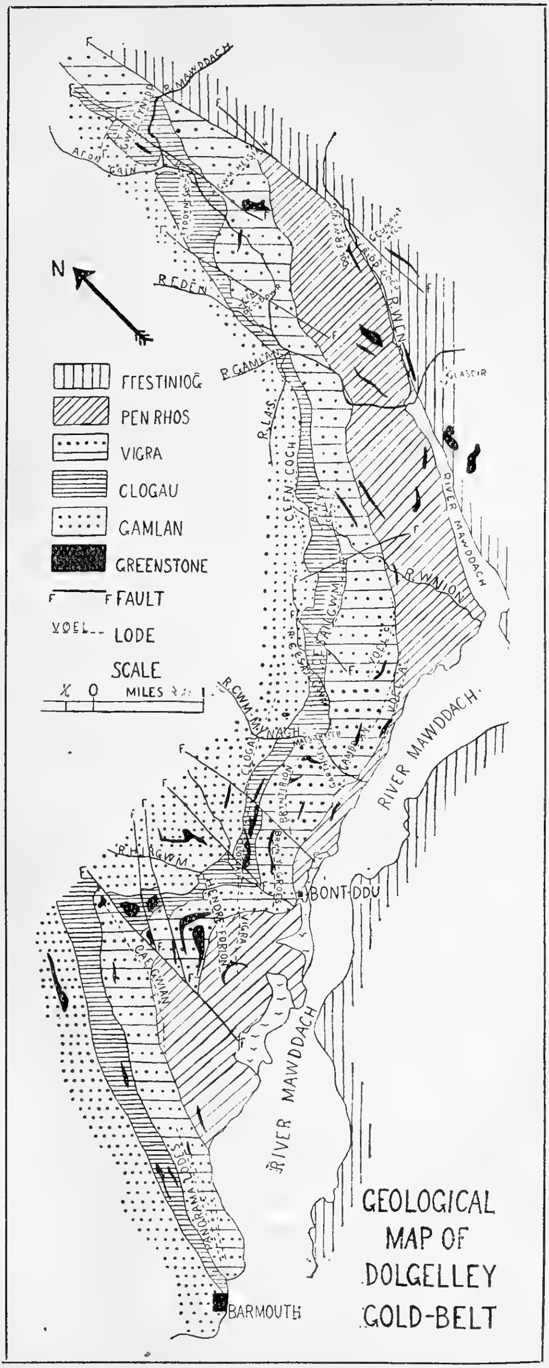
Coming nearer to the present, it is well to mention the belief of Readwin (31, p. 1) that gold was worked in Wales during the reign of Charles I. The facts on which Readwin bases his belief are as follows:—Thomas Bushell, between 1631 and 1645, rented royal mines in Merionethshire, near Barmouth; in 1636 he erected a mint at Aberystwyth, ostensibly to coin silver coin; he also coined £3 pieces and other gold pieces; Bushell gave and lent to Charles I some two and a half millions of our money; his was the only mint at the time not under the control of the Parliamentary forces, and thus able to supply the Royalists; Bushell could not have imported the gold into Wales, for he was hemmed in by the Parliamentary forces. Readwin thinks that Bushell worked the mines chiefly for gold; that he paid Charles one-tenth as royalty, and lent him nearly all the remainder, and that it was not in the interests of either to say anything about it.

At any rate, whether Bushell really worked gold or not, all knowledge of the existence of the precious metal in Merioneth was lost, and it was not until quite recent times that any more was heard of its occurrence. The honour of the discovery or re-discovery was claimed by four persons, of whom Mr. Arthur Dean was, at any rate, the first to publish any definite account; in 1844 he read a paper before the British Association (36) on the existence of gold at Dol-y-frwynog. Mr. Robert Roberts, of Dolgelley, however, claimed that he had discovered gold at Cwm-heisian in 1836 (40); he had had several samples assayed with highly satisfactory results, but believing that any gold-mine was a perquisite of the Crown (gold being a royal metal), he did not prosecute his investigations further till 1843; in the meantime he had informed Mr. Dean that gold and silver did occur in the county (37). Mr. O'Neill is supposed by some to have discovered gold at Cae Mawr in 1836 (40). The fourth claimant to the honour was Mr. James Harvey, proprietor of the mines at Cwm-heisian, who appears in 1836 to have called in Mr. Dean to report on the mines.

The gold-mining industry of the Dolgelley Belt, and of Merionethshire generally, may be said to have commenced in the year 1844. The first effort to raise capital to work the gold-mine was made in 1846, but the idea of profitable gold-mining in Wales only led to ridicule from the investing public. In 1847 the North Wales Silver, Lead, Copper, and Gold Mining Company, with a capital of £125,000, was floated to work the lodes of Vigra, Clogau, Tyddyn-Gwladys, and Dol-y-frwynog; this Company paid most attention to copper, but before 1849 the veins at Cwm-heisian had been thoroughly tested for gold; 300 tons of ore had been milled, and from the resultant $10\frac{3}{4}$ tons of concentrates $7\frac{3}{4}$ pounds of gold had been obtained, worth approximately £350 (41).

Throughout early years the Mines Royal Corporation was a constant obstacle to the progress of the gold-mining industry. This Corporation, by virtue of letters patent granted in Elizabeth's reign, claimed a monopoly of all gold and silver mines in the Principality. After a great amount of litigation a compromise was finally effected, and the Mines Royal Corporation accepted a royalty, which amounted to 5 per cent. of the gross output in the case of private lands and 10 per cent. in the case of Crown lands.

Stimulated no doubt by the gold discoveries of California and Australia, Wales in 1853 experienced a boom of the usual description, gold being reported from any and every part of the country. The mines worked during this period were mostly in the upper reaches of the Afon Mawddach, near to the old mines of Cwm-heisian and Tyddyn-Gwladys. Gold was found at this period in an old dump at the Vigra Mine by Messrs. Parry & Goodman, of Dolgelley (42), and also at the Prince of Wales Mine on the north side of the Mawddach estuary, immediately opposite the Penmaenpool railway station. In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R. WNION
R. CWM-MYNACH
CLOGAU
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VIGRA
RIVER MAWDDACH
BARMOUTH
GEOLOGICAL
MAP OF
DOLGELLEY
GOLD-BELT

1854 Clogau yielded its first gold from a single piece of stone worth £25; in 1856 a hundred pounds of picked quartz from Clogau yielded 14½ ounces of gold (43). In 1860 extensive and valuable finds were made at the St. David's Mine on the Clogau Hill, revealing the extraordinary richness of some of the pockets of this mine; on one day, for instance, 15 cwt. of quartz was mined which yielded between £500 and £600 of gold. In the first half of 1861, 983 ounces of gold, worth £3664, were obtained from the St. David's lode. In 1862 gold was met with in the Berth-lwyd Mine, near Tynygroes. In 1863 gold was discovered at the Ganllwyd, Tyddyn-Gwladys, Glasdir, Moel-offryn, Prince of Wales, Cae-mawr, Cambrian, and Garth-gell Mines, while active operations were in progress at the Cwm-heisian, Dol-y-frwynog, Cefn Coch, and Clogau Mines. The year 1864 witnessed the discovery of gold at the Gwyn-fynydd Mine, and in 1867 the Clogau Mine paid £22,575 in dividends.

Several tables have been published at various times showing the gold production of the Mawddach district from 1844 to 1866; these show considerable discrepancies. I produce here the one which is probably the most correct one; it is derived from official sources (45); the tables which I have omitted are to be found in the works of Phillips (46) and Dr. Ure (40, p. 698).

Gold Production of the Mawddach River District up to 1865.

	Ore.			Gold.		
	Tons.	Cwt.	Qrs.	Oz.	Dwt.	Grs.
Cambrian	50	0	0	30	0	1
Castell-carn-dochan	1132	0	0	888	0	0
Cefn-deuddwr	5	0	0	8	0	0
Clogau (before 1860)	30	0	0	200	0	0
Clogau (after 1860)	4493	15	3	11,493	2	16
Cwm-heisian	300	0	0	184	0	0
Dol-y-frwynog	312	1	2	167	5	5
Gwyn-fynydd	5	1	3	15	15	12
Mawddach River	1	4	0	2	0	0
Prince of Wales (Hafod-y-morfa)	20	0	0	63	0	0
Welsh Gold Mining Company (Cefn Coch)	1602	18	1	585	7	5
Total	7952	1	1	13,636	10	15

From 1866 to 1888 gold-mining in Merionethshire was practically stagnant, the *Vigra and Clogau* and the *Gwyn-fynydd* Mines being worked at intervals, the others not at all. In 1888 rich patches were struck in the Gwyn-fynydd Mine, and this mine has been worked almost continuously since then. For two years it did very well and produced over £38,000 worth of gold; then, encountering a bad year, it was forced to suspend operations, and the Company controlling it was succeeded by another Company which struck rich patches and made handsome profits. Since then the gold return from Merionethshire, practically all from this Dolgelley Gold-belt, has always been considerable, though it has been derived almost entirely from one or other or both of the two mines, the Vigra and Clogau and the Gwyn-fynydd. J. M. Maclaren, speaking of the years 1900 and 1901 (38, p. 447), said: "The net profits of the St. David's Gold and Copper Mines, Ltd. (the former Vigra and Clogau), for the year 1900 were £39,729, which admitted of the payments of dividends of 60 per cent. on the capital. While the gross receipts for that year were £51,344, the total expenses were only £8423, or 8*s.* 7$\frac{3}{4}$*d.* per ton. The royalties paid to the Crown were £2038, at the rate of 2*s.* 1*d.* per ton of ore crushed." In 1903 the St. David's Gold Mining Company controlled practically all the gold-mines of the district; work was actively pushed forward in the St. David's and Clogau Mine and in the Gwyn-fynydd Mine, and good results were obtained. This Company also did a great amount of development work at the Voel Mine—an amalgamation of the old Prince of Wales, Princess Alice, Moel Ispri, and Cambrian Mines. A large and well-designed mill was erected, principally for saving lead and zinc, but it did very little work.

A table is inserted on p. 206 showing the total production of gold and gold-ore in Merionethshire from 1861 to the present date, and at the same time showing the collective output of the St. David's (Clogau) and the Gwyn-fynydd Mines, the principal mines of the district.

Note.—The table is compiled from that given by J. M. Maclaren, and also from the Mineral Statistics of the United Kingdom for the years 1861 to 1896; from the Inspectors of Mines, Reports, 1880 to 1893; from the Mineral Industry of the United Kingdom, 1894 to 1896; from Mines and Quarries for 1896 to 1907. "Estimated value" of the ore at the mine as furnished to the Mines Department of the Home Office merely means the estimated profit that should accrue from the treatment of the ore, the estimated expenses of the year having been deducted. From 1865 to 1874, and also in 1877, 1883, and 1885, the value (actual) of the gold has been calculated from the weight, taking the value of the gold as £3 17*s.* per ounce. For the years 1905 to 1907 the value has been calculated from that of the total gold output of Wales.

The Lodes of the Dolgelley Gold-belt.

Practically all the auriferous veins of the Dolgelley Gold-belt have been worked to a certain extent; on many, operations have never proceeded beyond the prospecting stage; on others a very considerable amount of work has been done in opening up and developing the ore body. An account will now be given of the various lodes of the belt, commencing in the neighbourhood of Barmouth, and running thence eastward and northward.

Panorama Copper Lodes, Barmouth.—These are situated just above the main road from Barmouth to Dolgelley, and about 2 miles from the former place. There are numerous lodes on the property, of which four are prominent—

1. The gold lode, striking 30° east of north and usually nearly vertical; a few hand-specimens of gold were found here about 1860. In places this lode is well mineralized, chiefly with galena and also

Gold Production of Merionethshire.

Year.	Gold-ore.	Gold.		Estimated Value.	Actual Value.
		Merioneth.	St. David's, etc.		
	Tons.	Ounces.	Ounces.	£	£
1861 . .		2886	2886	—	10,817
1862 . .	804	5299	5299	—	20,391
1863 . .	386	553	527	—	1747
1864 . .	2336	2887	2337	—	9991
1865 . .	4281	1665	542	—	6408
1866 . .	2928	743	214	—	2859
1867 . .	3241	1320	1520	—	5853
1868 . .	1191	436	436	—	1678
1869 . .	—	—	—	—	—
1870 . .	—	191	191	—	735
1871 . .	—	—	—	—	—
1872 . .	—	—	—	—	—
1873 . .	—	—	—	—	—
1874 . .	—	383	383	—	1477
1875 . .	—	548	548	—	2106
1876 . .	—	289	289	—	1119
1877 . .	—	139	139	629	536
1878 . .	—	698	698	—	2825
1879 . .	22	447	447	—	1790
1880 . .	—	5	5	—	19
1881 . .	—	—	—	—	—
1882 . .	—	226	226	—	863
1883 . .	869	66	66	100	254
1884 . .	—	—	—	—	—
1885 . .	35	3	3	7	13
1886 . .	—	—	—	—	—
1887 . .	1	58	58	—	209
1888 . .	3844	8745	8745	27,300	29,982
1889 . .	6226	3890	3864	10,746	13,277
1890 . .	575	206	203	434	675
1891 . .	14,067	4002	4001	12,200	13,700
1892 . .	9990	2835	2835	9168	10,511
1893 . .	4489	2309	2299	7657	8619
1894 . .	6603	4235	4020	13,573	14,811
1895 . .	13,266	6600	6502	16,584	18,528
1896 . .	2765	1353	1208	4257	5033
1897 . .	4517	2032	1738	6282	7185
1898 . .	703	395	241	1158	1299
1899 . .	3047	3327	3203	10,170	12,086
1900 . .	20,802	14,004	13,790	42,925	52,147
1901 . .	16,374	6225	6159	13,920	22,042
1902 . .	29,953	4181	4133	12,621	14,570
1903 . .	28,600	5495	5464	16,995	19,308
1904 . .	23,303	19,653	19,653	68,576	73,925
1905 . .	15,540	5738	5738	17,600	21,006
1906 . .	17,025	1838	1811	5238	6453
1907 . .	12,956	1908	1887	5615	6218
Total .	250,739 (incomplete)	117,913	114,308	303,755 (since 1887)	423,065

with blende and chalcopyrite; the lode may be traced for over half a mile.

2. The north copper lode, parallel to the above and vertical; it varies in width from 2 inches to 2 feet, and there seems to be no system in its thickening and thinning. Like most of the Welsh gold lodes, its walls are ill-defined; it may be traced at intervals for about 1 mile. The quartz of this lode carries a great deal of chalcopyrite. Besides the weathering products of the copper pyrites, the only other mineral present is pyrrhotite, and that in small quantity only. There is a north and south lode, which intersects this lode, and to the west of the junction the main lode becomes much thinner, but much richer in copper.

3. The middle lode is south of the previous one; it strikes 40° east of north, is again practically vertical, and may be traced for half a mile. This lode is opened up at two levels: in the upper, good copper ore is found in the neighbourhood of a north and south cross-course; in the lower level (180 feet below) the lode is poorly defined and carries no copper values.

4. The north-and-south lode, which is not worked, is poorly mineralized; there is only a very small amount of galena, blende, and chalcopyrite. The lode is of importance only on account of the effect it appears to have on the copper values in the north copper lode. It dips strongly towards the west at an angle of about 45°.

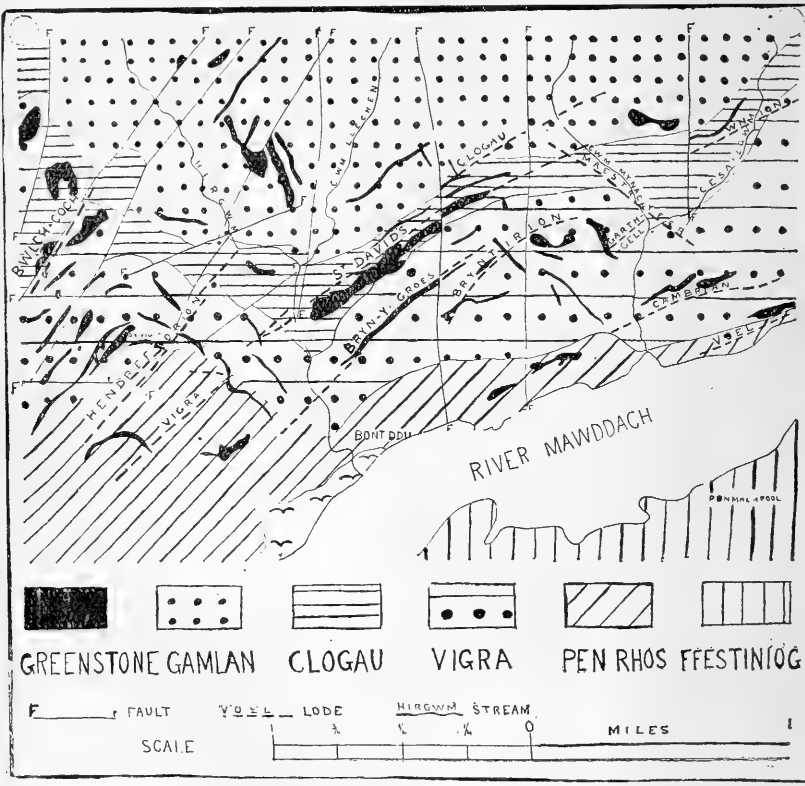
All these lodes are found in the Vigra Beds of the Maentwrog.

Cae-Gwian Lode.—This is a poorly defined and little developed lode, about 2 miles up the stream which flows into the estuary at Pont Glandwr. The strike of the lode is about 30° east of north, and the dip is 80° towards the west; it may be roughly traced for 1½ miles; the width is irregular, averaging about 1 foot. Copper pyrites and iron pyrites, with oxides of iron and manganese, are seen in the outcrops, and are present in very small quantity only. The southern end of the lode is seen in the Pen Rhos Beds; going north, the lode enters and crosses the Vigra, and finally in the Clogau Beds comes to a termination against the Llynbodlyn fault.

Farchynys Lodes.—On the edge of the estuary immediately south of Farchynys House, there are several outcrops of quartz belonging to three sets of vertical veins, striking 40° east of north; these can be traced only a short distance. The lodes are on the average about 2 feet wide, and are poorly mineralized. A small amount of mining work has been done and gold obtained, assays conducted by Readwin giving 6 dwt. of gold per ton. This lode lies well up in the Pen Rhos Beds of the Maentwrog.

Bwlch-coch-uchaf Lode.—To the east of the Cae-gwian lode, and on the east side of the Llynbodlyn fault, there is a parallel lode striking 30° east of north; it is only traceable for a distance of 500 yards; its width is about 1 foot on the average; copper pyrites and iron pyrites are seen in the lode. The lode cuts through the Vigra Beds and skirts the edge of a sill of greenstone.

Hafod-uchaf Copper Lode.—This is probably a continuation of the Bwlch-coch-uchaf lode, though no trace of a lode formation can be seen in the partially drift-coloured 1000 yards which intervene. The strike at Hafod-uchaf is 35° east of north, and the dip is in general towards the west at an angle of 80°. The lode branches frequently, the separated parts usually dying out in a very short distance. This Hafod-uchaf lode exhibits in many parts a banded structure due to the alternation and admixture of green shale and quartz. The lode is sometimes 7 or 8 feet in width, its average width, however, being about 3 or 3½ feet; the walls are fairly well defined. The prevailing minerals in the lode are quartz, chalcopyrite, and pyrites; no gold has been taken from this lode. In places the lode is very well



Geological Map of the St. David's section of the Dolgelley Gold-belt.

mineralized, but the average tenor of the ore is so much impoverished by long stretches of barren quartz that the lode has not paid working expenses. This lode cuts through the Gamlan Shales, and is intimately associated with an intrusion of greenstone which it intersects at several places.

Hendre-forion Lode.—Half a mile to the east of the Hafod-uchaf lode, i.e. a little to the north of the Hendre-forion Farm in the Hirgwm Valley, there is another parallel lode striking 30° east of north, which can be traced for half a mile; the dip is slightly towards the west. The lode ranges up to 6 feet in width, averaging about 1½ feet throughout its traceable length. The quartz is poorly mineralized, containing occasional pyrites only. The lode occurs in the Gamlan Shales, and runs along and across numerous greenstone intrusions; it occupies a fault plane which can be traced for several miles north and south.

West Vigra or Nant-goch Lode.—On the west side of the Vigra Mountain there are several abandoned copper workings close to the Nant-goch Farm. The lode worked can be traced for about 1½ miles over the shoulder of Y Vigra to the Hirgwm stream, and perhaps for half a mile beyond, its strike being 35° east of north. The part on the west flanks of Y Vigra used to be called the Nant-goch lode; that on the north flanks the West Vigra lode. The lode is vertical; in width it varies from a few inches up to 20 feet. Besides quartz the lode contains abundant chalcopyrite, pyrites, and pyrrhotite, with a little galena; the latter becomes the most common mineral where the lode crosses the shoulder of the Vigra spur. Assays of this lode in 1861 by Readwin (34) gave 13 grains of gold per ton. In the south the lode traverses the Pen Rhos Slates; towards the north it traverses the Vigra and Clogau Beds, and finally dies out in the Gamlan Shales. The lode as a rule runs along the junction of the sedimentary rocks and the many greenstone intrusions which occur along its course.

Vigra Lodes.—The Vigra Mine worked on two intersecting quartz lodes, which formed a conspicuous outcrop of white quartz high on the flanks of Y Vigra. One of the lodes strikes almost due east and west, dipping to the south at an angle of 70°. It can be traced for a distance of 300 yards only to the west of the workings, and here it has been worked to some considerable extent. In width it varies from 4 to 6 feet; the lode material is of clear white quartz, carrying in places chalcopyrite. The second of the lodes is more important; at the Vigra Mine its strike is 60° east of north, dipping 75° to the north; to the west it can be traced for a distance of 1000 yards; to the east it can be traced into the continuation of the St. David's lode. At the Vigra workings this principal lode system consists of two parallel veins about 30 yards apart, connected with each other by a series of leaders and cross-veins. Both these veins are irregular in width, swelling out to 6 feet and then pinching in to a few inches. A low-level cross-cut was driven to intersect the lode at a depth of about 400 feet below the upper workings, but was not successful in picking up the lode at that depth. The lode matter is quartz impregnated with copper pyrites; enclosed in the lode are blocks of black shale impregnated with chalcopyrite, bornite, erubescite, arsenopyrite, and to a small extent gold; in some parts the lode contains rhodonite; the mine waters are acid and carry copper in solution. At the Vigra workings where the lode is best developed, it crosses the Vigra Beds of the Maentwrog; to the west it crosses the Pen Rhos Beds, while to the east it enters the Clogau Beds. Where the lode is most prominent it is accompanied by intrusive greenstones.

Clogau and St. David's Lode.—This and the Gwyn-fynydd lode, which will be mentioned later, are the principal lodes of the Dolgelley Gold-belt. The easterly continuation of the main Vigra lode, known as the Clogau and St. David's lode, runs up over the shoulder of the Clogau Hill and down the other side to the Afon Cwm-Mynach. Near the top of the hill it is cut across by the north and south Bryntirion fault, which moves the eastern end 100 yards to the north. This eastern end has been known as the St. David's lode, the western end as the Clogau. After it passes over the Clogau Hill the lode becomes thinner and poorer, and little work has been done on it. The lode continues, however, as the Cae-mab-seifion lode. On the slopes of Clogau the lode has been worked for a distance of about 1 mile; the combined outcrops of the continuous Vigra, Clogau, St. David's, and Cae-mab-seifion lodes may be traced for about 3½ miles, the longest known line of outcrop in the Dolgelley Gold-belt.

The strike of the Clogau lode is 35° east of north, the dip being vertical with slight oscillations to either side. For a great distance the lode lies among the Clogau black slates, to which it runs parallel in strike though not in dip; throughout its whole length in the Clogau Beds it is intimately associated with the Llech-fraith greenstone sill. The walls of the lode very often show slickensides, and are in most places separated from the vein-stuff by more or less distinct clayey selvages. To the north-east the lode leaves the Clogau Beds and traverses the Gamlan Shales, where it is associated with very few greenstones.

The lode, or rather lode system, branches into parallel veins connected by cross-veins and stringers; thus there are three lodes in the St. David's Mine—the north, the main, and the south; to the south-west they unite to form one lode with frequent stringers and offshoots. These individual lodes vary greatly in width, ranging from 20 feet down to streaks, inches only in thickness.

Fragments of the wall rock frequently appear in the vein-stuff of the lodes, and these black, often talcose fragments of shale may at times give a brecciated appearance to the vein. The vein often has a banded structure, due to stringers or bands of slate or greenstone, separated from each other by bands of white quartz; drusy cavities are common. In addition to the white quartz and calcite which carries little besides pyrites and pyrrhotite, there is also a dark quartz, discoloured by inclusions of minerals and particles of the country rock. Pyrites, pyrrhotite, chalcopyrite, galena, blende, arsenopyrite, tetradymite, and gold occur, chiefly in the darker quartz; of these, gold and chalcopyrite are the only ones that occur in abundance.

During the years of which full returns have been published (1861–1907), these lodes have returned 77,501 ounces of gold from 145,080 tons of quartz. Analyses of gold from the Clogau lodes gave the following results (27):—

	Gold.	*Silver.*	*Quartz.*	*Iron.*	*Copper.*	*Loss.*	*Total.*	*S.G.*
(1)	90·16	9·26	·32	trace	trace	·26	100·00	17·26
(2)	89·83	9·24	·74	trace	—	·19	100·00	15·62

The gold is very variable in its distribution, the rich patches being found in a most unevenly scattered system of pockets. Some of the pockets are very rich; in one case 130 ounces of mixed quartz and gold, broken from the lode, were melted down direct, giving 116 ounces of retorted gold. The pockets are, as a rule, found in the bands of dark bluish quartz, not in the white quartz. They are frequently associated with the included fragments of the Clogau Slates; and crystals of gold, along with other minerals, may be seen adhering to the slaty surface. The occurrence of tetradymite is regarded by the miners as a favourable indication for gold.

It is certain that the wall rock has some effect on the distribution of the gold, for so far not a single pocket has been found where the lode has entered into the Gamlan Shales.

In the grits and greywackes of the Barmouth Series, immediately to the north of the lode, many fractures or cross-courses may be seen, which run straight towards the lode and intersect it. It is most probable, indeed, that these fractures are responsible, in part at any rate, for the distribution of the pockets, as they afford an easy channel for the passage of mineral solutions containing gold or some precipitant of gold. In many cases, the shoots of gold run more or less transversely across the lode; a system of cross-courses certainly favours such a distribution. In 1875 (40, p. 695) it was noticed that the lode was very rich behind one of these cross-courses. The possible importance of these cross-courses on the distribution of the pockets in the mine has not, however, been recognized, as no systematic attempt seems to have been made to follow the cross-courses in the search for the rich pockets.

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

III.—Sedgwick Museum Notes.

New Fossils from the Dufton Shales.

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

Part I.

(PLATE XVI.)

A SMALL collection of fossils was made a few years ago by Mr. V. M. Turnbull from a cutting on the Alston Road, near Melmerby, and the author[1] has already described a new species of *Lichas* (*L. melmerbiensis*) which was included amongst them. Several more new species of trilobites and other groups are now described, and the complete list of the fauna is as follows[2]:—

Trilobita.

Phacops apiculatus, Salt.*
Calymene senaria (Salt., non auctt.).
C. Caractaci, Salt.
Trinucleus Nicholsoni, sp. nov.*
Acidaspis semievoluta, sp. nov.
Lichas melmerbiensis, Reed.*
Törnquistia Nicholsoni, Reed.
Homalonotus bisulcatus, Salt. (?).
Homalonotus cf. *Edgelli*, Salt.
H. ascriptus, sp. nov.
Illænus Bowmani, Salt. (?).

Ostracoda.

Beyrichia (*Tetradella*) *Turnbulli*, sp. nov.
B. (*Ctenobolbina*?) *superciliata*, sp. nov.
B. (*Ceratopsis*) *duftonensis*, sp. nov.*
Turrilepas sp.

Mollusca.

Cyrtolites aff. *ornatus*, Conr.
Bellerophon (*Sinuites*) sp.
B. (*Oxydiscus*) *acutus*, Sow. (?).
Cyclonema aff. *crebristria*, McCoy.
Holopea sp.

[1] Reed, Geol. Mag., 1907, Dec. V, Vol. IV, pp. 396–400, Pl. XVII.

[2] For other lists of fossils from the Dufton Shales, see Harkness, Q.J.G.S., 1865, vol. xxi, p. 248; Harkness & Nicholson, ibid., 1877, vol. xxxiii, pp. 462–3; Marr & Nicholson, ibid., 1891, vol. xlvii, pp. 505, 511.

Pleurotomaria (?) sp.
Trochonema sp.
Tentaculites sp.
Conularia aff. *plicata*, Slater.
Ctenodonta (?) sp.
Pterinea (?) sp.

BRYOZOA.

Crisinella Wimani, sp. nov.
Monotrypa (?) sp.

BRACHIOPODA.

Lingula tenuigranulata, McCoy.*
Lingula sp.
Orbiculoidea perrugata, McCoy.
O. oblongata, Portl.*
Acrotreta Nicholsoni, Dav. (?).
Siphonotreta scotica, Dav. (?).
Orthis unguis, Sow.*
O. testudinaria, Dalm.*
O. Actoniæ, Sow.
O. duftonensis, sp. nov.
O. melmerbiensis, sp. nov.
O. turgida, McCoy (?).
O. (*Scenidium* ?) *equivocalis*, sp. nov.
Strophomena (?) sp.*
Leptæna rhomboidalis (Wilck.).

INCERTÆ SEDIS.

Pasceolus sp.

CRINOIDEA.

Stem joints (round and pentagonal).

The species marked thus * are most abundant.

TRILOBITA.

TRINUCLEUS NICHOLSONI, sp. nov. Pl. XVI, Figs. 1–9.

Head-shield rather more than a semicircle, widest across middle, somewhat contracted at base; posterior margin inclined to lateral margin on each side at 75°–80°; fringe sloping downwards but not steeply inclined, slightly produced backwards at genal angles which are furnished with long spines. Glabella pyriform, much elevated and swollen, most so anteriorly, gradually decreasing in width and height posteriorly to occipital ring without forming neck; front end projects slightly beyond cheeks to fringe or overhangs the inner row of pits; small median tubercle present on surface of glabella, and on each side near its base are two pairs of small deep pits in axial furrows, the posterior pair in occipital furrow. Occipital ring narrow, nearly as elevated as glabella, separated off by shallow furrow, and furnished posteriorly with a short stout spine directed backwards and upwards at an angle to the general plane of head-shield and about one-third the length of the glabella. Cheeks forming spherical triangles, longer than wide, less swollen and elevated than glabella, highest along axial furrows, with posterior outer angle rounded, and minute granulation over whole surface. Fringe inclined, sloping downwards and widening to genal angles which are provided with long tapering genal spines curving first slightly inwards and then outwards. In anterior part of fringe are four rows of equal-sized pits arranged regularly in concentric and radial rows; the pits in outermost row are sometimes rather smaller. On the lower surface of the fringe the two outermost concentric rows are separated from the inner ones by a strong concentric ridge continued back to the genal angles and longitudinally along the spines. In front of and at the side of the cheeks the fringe widens slightly, and inside the four regular rows are introduced one or two shorter concentric rows of smaller pits with less distinct radial arrangement, so that 5–6 rows with a few smaller irregularly developed pits can be detected at the posterior outer angles of cheeks rounding them off. In some specimens the pits near the genal angles tend to be alternate. The true genal angle (i.e. the base of the spines where the pitted fringe ends) is level with the second or third thoracic segment, and the posterior and lateral edges of the head-shield meet here at about 75°–80°. Neck-segment behind cheeks narrow, rounded, marked off by distinct but weak furrow. Surface of fringe coarsely granulated.

Thoracic axis about one-sixth the width of thorax, narrow, prominent, cylindrical, with pair of deep pits in furrows between the rings inside and above axial furrows. Pleuræ of usual type, narrow, horizontally extended, flat, with strong diagonal furrow running to obliquely truncate tip. Inner edge of backwardly produced genal angles of fringe overlaps ends of first three pleuræ.

Pygidium broadly triangular; axis long, narrow, conical, reaching posterior edge, less than one-fifth width of pygidium, composed of 9–10 rings, of which the first 3–5 are distinct and well separated by transverse furrows deepest at sides. Lateral lobes flat, horizontal, with traces of 4–6 radiating fine grooves on each side separating the flat pleuræ and corresponding to axial rings. Margin of pygidium bevelled, steeply inclined.

		mm.
Dimensions.	Length of head-shield (without spine) . .	10–15
	Width of head-shield	20–25

Remarks.—The characters and shape of the glabella separate this species from *T. seticornis*, for it is not divided into a swollen frontal lobe and depressed cylindrical neck, though the more or less inclined fringe and position of the concentric ridge on its lower surface and median tubercle on the glabella are features in common. *T. Bucklandi*, Barr., as represented in the Girvan district,[1] has the glabella differing in the same way, and the genal angles are much more produced backwards. The shape of the glabella and presence of nuchal spine are much like *T. Bureaui*, Oehlert,[2] but otherwise the head-shield is distinct. In *T. concentricus*, Eaton,[3] it is the glabella, not the occipital ring, which is produced backwards into a spine; only the outermost row of pits on the fringe is separated off by the concentric ridge on the lower surface, and there are no lateral slits or pits near the base of the glabella; the radial arrangement of the pits on the fringe is not as a rule so well marked in any of the American specimens which I have examined, and there is no median tubercle on the glabella, though its general shape is very similar. The British forms referred by various authors to *T. concentricus* vary so greatly that probably more than one species, or at any rate several distinct varieties, have been included. Amongst the varieties recognized by Salter, *T. favus*[4] bears some resemblance to *T. Nicholsoni* in the shape of the glabella with pits at its base and in the presence of a nuchal spine, but the fringe has different characters. *T. fimbriatus*, Murch.,[5] does not seem to be closely allied.

We may draw particular attention to the resemblance of this

[1] Reed, *Girvan Trilobites* (Palæont. Soc.), 1903, pt. i, p. 10, pl. i, figs. 10–14.
[2] Oehlert, Bull. Soc. Géol. France, 1895, vol. xxiii, p. 300, pl. i.
[3] Hall, *Palæont. N.Y.*, 1847, vol. i, pp. 249, 255, pl. lxv, figs. 4*a–c*; pl. lxvii, figs. 1*a–h*.
[4] Salter, Mem. Geol. Surv., vol. ii, pt. i, pl. ix, fig. 5; id., Dec. Geol. Surv., 1853, vol. vii, pl. vii, p. 6.
[5] McCoy, *Brit. Palæoz. Foss.*, 1851, p. 146, pl. i E, fig. 16.

species to some of the so-called varieties of *T. concentricus* from Tyrone which Portlock described as distinct species. The form ascribed by B. Smith [1] to Portlock's *T. elongatus*,[2] under the designation of *T. concentricus* var. *elongatus*, has a nuchal spine similar to *T. Nicholsoni* and more elongated cheeks and glabella than in the true *T. concentricus*; apparently there is a median tubercle present, and there is mention made of "incipient furrows" at the base of the glabella which correspond to the pits in the axial furrows described in the Dufton species. But the pits in the fringe at the genal angles are more numerous in the Tyrone examples. In the form termed *T. concentricus* var. *Portlocki* by Smith,[3] it is remarked that the three rows of pits in front of the glabella tend to become confluent in a radial direction, as rarely in *T. Nicholsoni*. The Shropshire specimens referred to *T. concentricus* have the pits of the concentric rows arranged alternately, so that the radial arrangement is lost (as in examples of this species from Cincinnati), whereas in many of the Welsh specimens there is a radial regularity observable. Barrande's *T. ornatus* (Sternb.)[4] seems closely allied to our Dufton species in the shape of the head-shield, nuchal spine, pits in axial furrows, tubercle on glabella, and radial arrangement of the pits on the fringe; but these pits are more numerous and smaller. Further investigation will, it is believed, establish the specific independence of several British forms.

EXPLANATION OF PLATE XVI.

TRINUCLEUS NICHOLSONI, sp. nov.

FIG. 1. Head-shield, with portion of thorax attached, showing impression of lower surface of fringe with concentric ridge and genal spines. × 2.
,, 2. Head-shield, showing ditto. × 2.
,, 3. Head-shield, showing upper surface of fringe, etc. × 2½.
,, 3*a*. Portion of fringe. × 10.
,, 4. Head-shield. × 3.
,, 5. Ditto. × 2½.
,, 6. Impression of upper surface of fringe and cheek. × 2½.
,, 7. Nearly complete head-shield. × 2½.
,, 7*a*. Side-view of same, showing nuchal spine. × 2½.
,, 8. Head-shield, showing impression of lower surface of fringe. × 2½.
,, 8*a*. Side-view of same, showing impression of concentric ridge. × 2½.
,, 9. Pygidium. × 2.

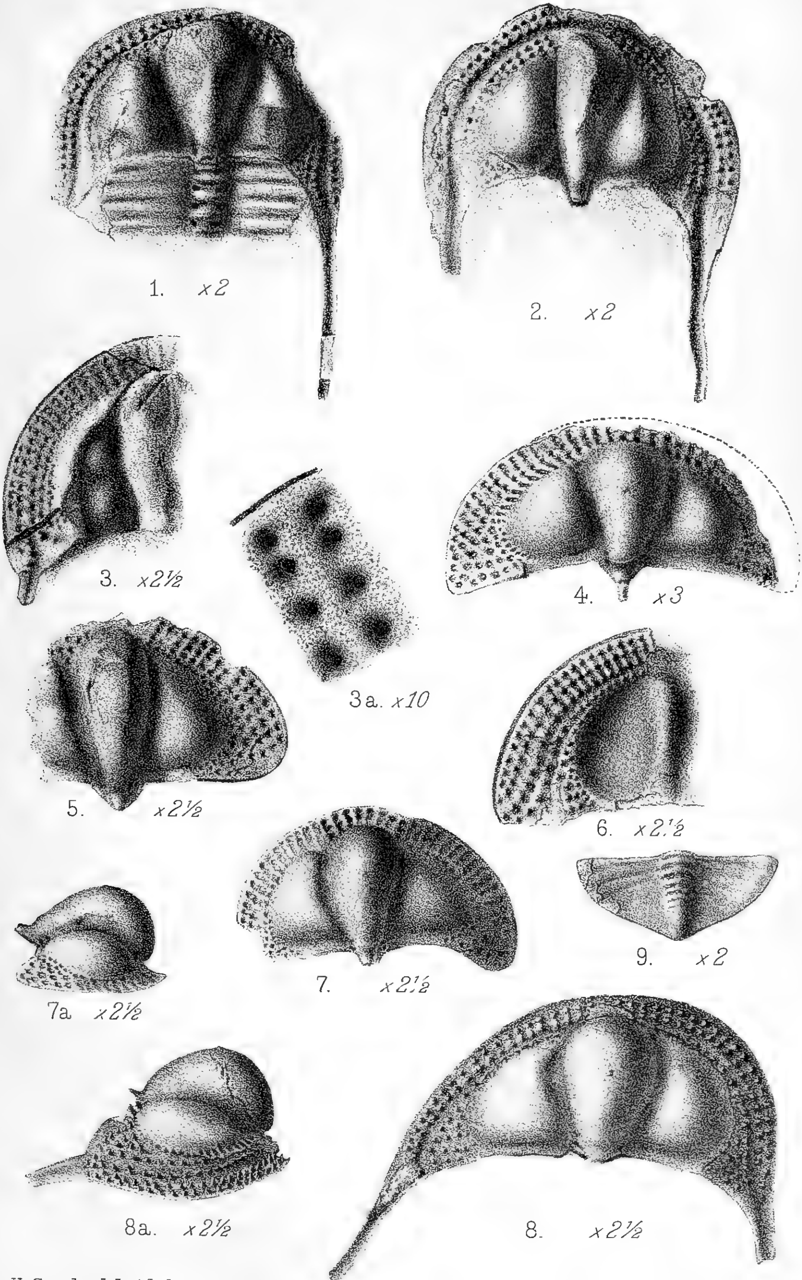
Part II.

(PLATE XVII.)

ACIDASPIS SEMIEVOLUTA, sp. nov. Pl. XVII, Figs. 1–3.

Head-shield semicircular, with middle part projecting behind base of cheeks. Glabella moderately convex, oval, widest across middle, well defined by strong continuous curved axial furrows; lateral lobes

[1] B. Smith, Proc. Roy. Irish Acad., 1907, vol. xxvi, sect. B, No. 9, p. 122, pl. viii, figs. 3, 4.
[2] Portlock, *Geol. Rep. Londond.*, p. 263, pl. i B, fig. 7.
[3] B. Smith, op. cit., p. 121, pl. viii, figs. 1, 2.
[4] Barrande, Syst. Silur. Bohême, vol. i, p. 623, pl. xxix, figs. 1–9; pl. xxx, figs. 41–60.



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

Trinucleus from Dufton Shales.

completely circumscribed, except first pair. Basal lobes large, oval, swollen, half the length and one-third the width of the glabella, and placed parallel to its longitudinal axis. Middle lateral lobes sub-circular, invading sides of axial lobe of glabella. Anterior lateral lobes very small, imperfectly separated from anterior lateral angles of axial lobe. Axial lobe of glabella sub-cylindrical, rather more than one-third the width of glabella at base, expanding again between basal and middle lateral lobes and again in front, with anterior lateral angles small and overhanging anterior lateral lobes; anterior end of glabella sub-truncate.

Fixed cheek narrow, curved, convex, rounded, increasing slightly in width posteriorly, embracing side of glabella back to eye, where it has about one-fifth the basal width of the glabella; behind eye descends steeply to narrow neck-ring; posterior lateral wing of fixed cheek somewhat flattened, extending horizontally outwards to facial suture. Ocular ridge forming very narrow rounded band outside fixed cheek, running back to eye. Eyes small, situated very far back, lying behind the middle of basal lobes of glabella, and at about two-thirds their width from axial furrows. Facial sutures curving steeply backward to eyes, running almost parallel to axial furrows; behind eyes bending out very sharply (nearly at right angles to anterior branch) to follow a course nearly parallel to posterior margin of head-shield before curving back to cut this margin at a distance from the axial furrows nearly equal to width of glabella.

Occipital segment forming broad flattened band projecting behind cheeks, and having a width equal to nearly one-third the length of the glabella, narrowing laterally behind basal lobes where it rises into a pair of small oval nodules. Occipital furrow strong, straight. Neck-segment very narrow. Free-cheek triangular, convex, sloping down from eye to concave marginal part, with strong raised narrow angulated border, bearing about twelve equidistant recurved short spines, successively increasing in length towards genal angle. Whole surface of head-shield tuberculated.

Pygidium (imperfectly known), broadly semicircular, with strongly convex prominent short sub-cylindrical axis, one-third the width of pygidium and not reaching posterior margin, composed of two distinct rings (with traces of a third) of which the first is by far the most prominent, and is ornamented with a single row of tubercles. Margin of pygidium armed with five pairs of spines, of which the first two pairs are small, short, slender, sub-equal, and directed radially outwards (these are somewhat indistinct and uncertain); third pair stouter and longer than the rest, nearly as long as pygidium, slightly divergent and connected as curved ridges across lateral lobes with first axial ring; two posterior and inner pairs of spines sub-parallel, slender, sub-equal, and directed backwards.

		mm.
Dimensions.	Length of head-shield	8·0
	Width of glabella	6·0
	Length of glabella	5·5
	Length of pygidium (without spines)	3·0

Remarks.—Two good head-shields, one free-cheek, and a somewhat imperfect pygidium form the material available. The head-shield much resembles that of the species termed *A. evoluta*, by Törnquist,[1] from the *Leptæna* limestone, but the pygidium of this form is unknown. A new species (undescribed) from the Starfish Bed, Girvan, also possesses many points of similarity, both in the head and pygidium. The free-cheek is somewhat like that of *A. callipareos*, Wyv. Thomson.[2]

HOMALONOTUS ASCRIPTUS, sp. nov. Pl. XVII, Figs. 4–8.

There is an imperfectly known species of *Homalonotus* occurring in the Dufton Shales which differs in certain particulars from *H. bisulcatus*, to which it is allied, and may be separated as a new species under the name *ascriptus*. The glabella is narrower, longer, and more cylindrical, the sides are nearly straight and the anterior end is more abruptly truncated, resembling in these respects that of the small head-shield from Horderley, figured by Salter (Mon. Brit. Trilob., pl. x, fig. 10), which he considered might possibly belong to *H. Edgelli*, a species founded on a pygidium. Close to the base of the glabella the axial furrows, which are deep, straight, and not sinuous (as they are in *H. bisulcatus*), diverge a little. The cheeks are narrower, more elevated and swollen, especially in the young individuals (Figs. 6, 7), than in the last-named species, particularly near the eyes, which are placed rather further forward. The pre-glabellar portion of the head-shield is narrower, being only about one-fourth the length of the head-shield, and is flattened and bent upwards, while the anterior margin of it is straight. The occipital segment and furrow seem developed as in *H. bisulcatus*. The anterior branches of the facial sutures run back to the eyes almost parallel, and the posterior branches curve out strongly in the usual way from the eyes, bending back finally to cut the posterior margin at a distance from the axial furrows about equal to the whole basal width of the glabella. The free-cheeks are unknown. A remarkable feature is that on the larger specimens the whole surface of the head-shield is covered with closely set small tubercles, which near the anterior lateral angles of the glabella are developed on the cheeks into minute erect sharp spinules, and this character alone would seem sufficient to separate this species from *H. bisulcatus*.

In the smaller specimens referred somewhat doubtfully to this species the surface of the shell is not preserved, but the eyes and cheeks are more perfect (Figs. 6, 7).

A small hypostome (Fig. 8) about 3 mm. long, of a sub-quadrate shape, may belong to this species; it is nearly parallel-sided and as wide as long; the body is rounded, weakly convex, clearly marked off from the border, has a pair of long lateral furrows running obliquely back from the anterior corners at a small angle to the sides for about three-fourths its length; the border is rounded and somewhat swollen at the sides with small obtuse anterior wings; the posterior border is wider, marked off by a strong furrow deepened at the ends.

[1] Törnquist, Siljans. Trilobitf. (Sver. Geol. Undersokn., 1884), ser. c, No. 66, p. 28, t. i, fig. 54.
[2] Reed, *Girvan Trilobites*, 1904, vol. ii, p. 112, pl. xv, figs. 11, 13.

		I.	II.
		mm.	mm.
Dimensions.	Length of head-shield	16·5	c. 8·0
	Length of glabella + occipital ring	13·5	7·5
	Width of glabella at base	9·5	5·0
	Width of glabella at front end	7·0	4·0
	Width of head-shield between eyes	14·0	8 0
	Width of head-shield at base	—	16·0

OSTRACODA.

Beyrichia (Ceratopsis) duftonensis, sp. nov. Pl. XVII, Figs. 9–11*a*.

Carapace semi-ellipitical, slightly oblique, rather elongate, widening a little posteriorly; anterior end somewhat pointed; posterior end wider and obliquely truncate above or rounded. Hinge-line straight, as long as carapace. Valves moderately convex, crossed by three swollen rounded lobes united below by sharp narrow sub-marginal ridge elevated into a thin rib on its crest running along middle of anterior lobe, then concentrically with ventral margin, then up posterior lobe, bending obliquely forward to ascend to summit of the upstanding process of this lobe. Anterior lobe with a width about one-third the length of valve, narrowing slightly below, more or less swollen and rounded; first sulcus rather obliquely inclined backwards, traversing three-fourths the width of the shell; middle lobe narrow, prominent, straight, vertical, nearly reaching marginal furrow below; second sulcus straighter and more vertical than first sulcus; accessory lobe represented by small node or tubercle almost isolated, situated about half-way down posterior lobe and separated from it by strong oblique sulcus, which is continued backwards to about middle of posterior margin, expanding somewhat and dividing the posterior lobe into two unequal parts, of which the lower forms a small elongated elliptical lobe, obliquely directed upwards and forwards with the accessory lobe at its upper end; the upper portion of the posterior lobe is strongly elevated, rising nearly at right angles to valve, and projecting a little above hinge-line as a blunt sub-conical process with flattened posterior face, and with its lower edge sharpened by the continuation of the sub-marginal crest, and beaded or fimbriated. Border flattened, set at right angles to plane of valves, with median narrow raised rim ornamented with a row of closely placed small tubercles. Surface of valves smooth.

		mm.
Dimensions.	Length	2·75–3·0
	Width	1·75–2·0

Remarks.—The relations of this species are wide. The raised process on the posterior lobe closely resembles that of *B.* (*Cer.*) *oculifera*, Hall,[1] but the border of the valves is different. The crest on the lobes recalls the sub-genus *Steusloffia*,[2] and similar crests are present in *Strepula*,[3] but they have no genetic significance. With *B.* (*Cer.*) *Chambersi*, Miller,[4] our species agrees in the reduction or

[1] Jones, Q.J.G.S., 1890, vol. xlvi, p. 21, pl. iv, figs. 19, 20; Ulrich, Proc. U.S. Nat. Mus., 1908, vol. xxxv, p. 308, pl. xxxix, figs. 19, 20.

[2] Ulrich, op. cit., p. 295, pl. xxxviii, figs. 1–5.

[3] Jones, *Ann. Mag. Nat. Hist.*, 1885, ser. v, vol. xvii, p. 403.

[4] Miller, Cincinnati Quart. Journ. Sci., 1874, vol. i, p. 234, fig. 27.

obsolescence of the accessory lobe, and in the division of the posterior lobe, but the division is not so complete in *B. Chambersi*, nor the posterior horn so long and pointed and recurved. The complete division of the posterior lobe is more like that in the *B. tuberculata* group, but the lobes are connected ventrally. The posterior lobe is divided in *B.* (*Cer.*) *quadrifida*, Jones,[1] and there is a somewhat similarly situated accessory lobe.

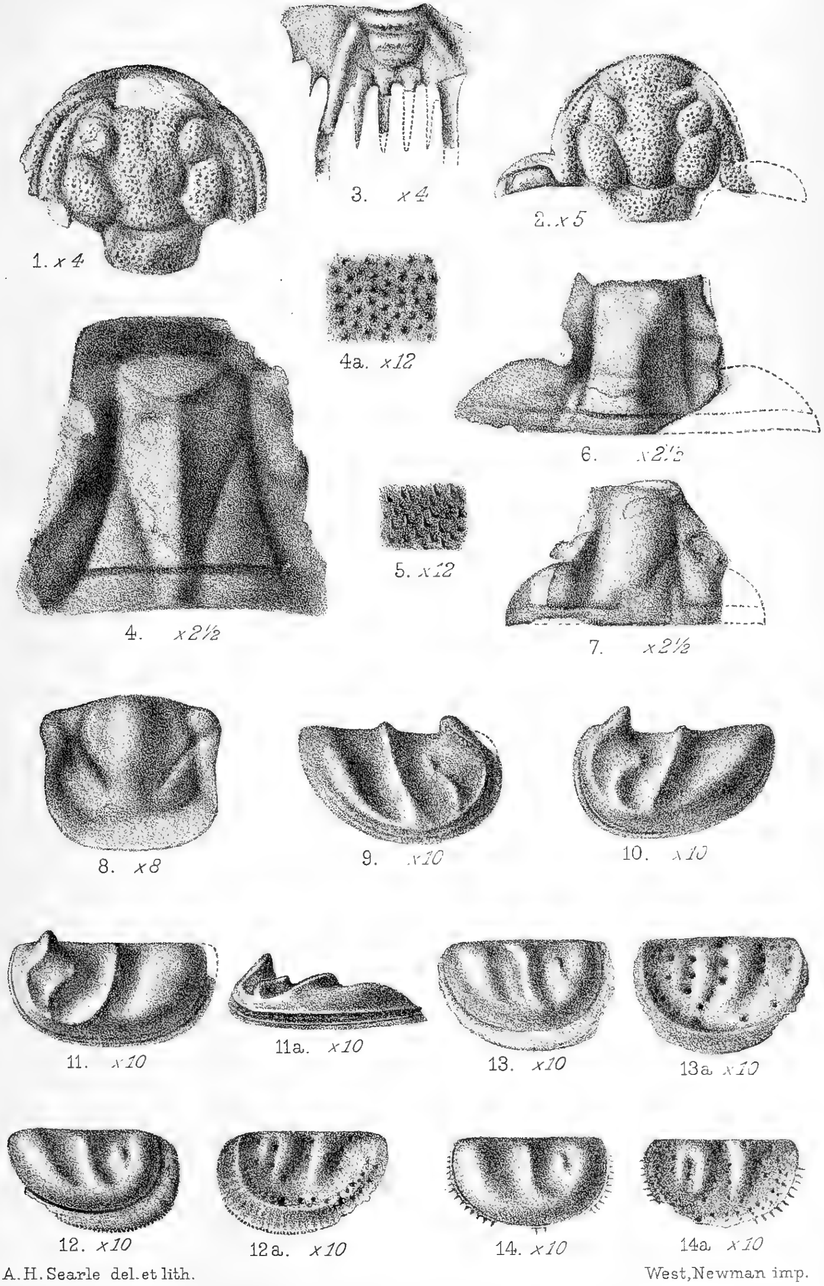
Beyrichia (Ctenobolbina?) superciliata, sp. nov. Pl. XVII, Figs. 14, 14*a*.

Carapace small, semi-elliptical, about twice as long as wide, with rounded sub-truncate ends, sub-rectangular cardinal angles and hinge-line somewhat shorter than maximum length of carapace; anterior and posterior ends of sub-equal size. Valves rather convex, crossed by three lobes of unequal size and development, with a fourth smaller accessory one on inner side of posterior lobe; all lobes united below and merging into rounded sub-marginal ridge. Anterior, posterior, and ventral margins thick, with narrow flange projecting above the border and bearing a row of delicate radiating short straight spines set at equal distances apart; border thickened, inclined at right angles to plane of valves and widening somewhat posteriorly. Anterior lobe on valves broad, somewhat swollen, rounded, in width equal to about one-third the length of the valve; first sulcus nearly vertical, at right angles to cardinal edge and extending about one-half to two-thirds of the distance across valve; second lobe narrower than anterior one, sub-median in position, more prominent near dorsal edge, slightly curved back ventrally; second sulcus sub-parallel to first, of sub-equal length, a little wider dorsally and slightly curved back ventrally below accessory lobe; posterior lobe as large (or nearly so) as anterior one, with small accessory tubercular lobe about half-way up its inner slope, elongated and nearly vertical and almost circumscribed by furrows; accessory furrow short, connected above with second sulcus. Surface of valves minutely granulated, and dotted with a few small scattered tubercles which are especially numerous and have a roughly concentric arrangement near ventral margin; a specially large tubercle is situated close to the cardinal edge on each of the three main lobes and usually two near the ventral margin; three smaller ones are usually present in a vertical line on the middle lobe.

		mm.
Dimensions.	Length . .	about 2·25
	Width . .	about 1·50

Remarks.—This species closely agrees with *B. ciliata*, Emmons,[2] but the presence of the small accessory lobe, the narrower posterior lobe, and the situation of the spines on the flange instead of along the edge of the valves sufficiently distinguish it. In the *B.* (*Ct.*) *subcrassa* section of the genus or sub-genus *Ctenobolbina* there sometimes exists, according to Ulrich,[3] a similar small accessory lobe.

[1] Jones, *Contrib. Micro. Palæont. Canada*, 1891, pt. iii, p. 66, pl. xi, figs. 19*a*, *b*.
[2] Jones, Q.J.G.S., 1890, vol. xlvi, p. 19, pl. iii, figs. 12–15; pl. iv, figs. 16–18.
[3] Ulrich, Proc. U.S. Nat. Mus., 1908, vol. xxxv, p. 309.



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

New Crustacea from the Dufton Shales.

BEYRICHIA (TETRADELLA) TURNBULLI, sp. nov. Pl. XVII, Figs. 12, 12*a*, 13, 13*a*.

Carapace obliquely semi-elliptical, somewhat elongated with hinge-line as long as carapace and anterior end somewhat narrower than posterior, which is broadly rounded. Valves moderately convex, divided by three unequal sulci into four lobes, all connected ventrally with rounded sub-marginal ridge. Anterior lobe largest, more or less swollen and pear-shaped, in width equal to quite one-third the length of carapace, narrowing ventrally; first sulcus longest and widest, slightly oblique or curved back below, but starting at right angles to cardinal line, extending about two-thirds to three-fourths across the valve; middle lobe almost median, narrow, rounded, about one-half the width of anterior lobe, at right angles to cardinal edge; second sulcus sub-parallel to first, slightly oblique, of same strength as first; accessory lobe smallest of all, more or less nodular, not reaching cardinal edge, situated on inner side of posterior lobe, and connected by depressed narrow neck with sub-marginal ridge; accessory furrow short, weaker than others; posterior lobe rounded, about two-thirds the width of anterior lobe or nearly as large. Border of valves with horizontally extended rounded convex flange, separated off by deep marginal furrow; flange very narrow in front, widening posteriorly, crossed by regularly placed faint radial grooves, with fine striæ on edge, making a minutely fimbriated and denticulated margin. Anterior end of valves provided with a few small marginal spines set along the edge of border below the flange. Surface of valves minutely granulated, with an irregular concentric row of small sub-equal tubercles close inside marginal furrow, becoming a double row below anterior lobe and at front end; a few larger tubercles irregularly distributed on the lobes.

		mm.
Dimensions.	Length	about 3·00
	Width (across middle) . .	about 1·25

Remarks.—We may compare this species with *B.* (*Tetr.*) *marchica*, Krause,[1] and *B. subquadrans*, Ulrich,[2] but the lobation, character of the flange, and ornamentation of our species do not completely agree with either. In *B. complicata*, Salter,[3] the valves are shorter and wider, and the lobes are not developed relatively in the same manner; the surface also is smooth (except in the variety *decorata*), and the flange and ornamentation are distinct in character.

EXPLANATION OF PLATE XVII.

FIG. 1. *Acidaspis semievoluta*, sp. nov. Head-shield without free-cheeks. × 4.
,, 2. Ditto, ditto. × 5.
,, 3. Ditto. Imperfect pygidium. × 4.
,, 4. *Homalonotus ascriptus*, sp. nov. Head-shield without free-cheeks. × 2½.
,, 4*a*. Ornamentation of ditto. × 12.
,, 5. Ditto. Ornamentation of head-shield near anterior lateral angles of glabella. × 12.
,, 6. Ditto. Head-shield of young individual (?) without free-cheeks. × 2½.

[1] Krause, *Zeits. deutsch. geol. Ges.*, 1889, xli, p. 19, t. ii, figs. 9–11.
[2] Ulrich, op. cit., p. 306, pl. xxxix, figs. 1–3.
[3] Jones, *Ann. Mag. Nat. Hist.*, 1855, ser. II, vol. xvi, p. 163, pl. vi, figs. 1–5.

FIG. 7. *Homalonotus ascriptus*, sp. nov. Head-shield. × 2½.
,, 8. Ditto. Hypostome. × 8.
,, 9. *Beyrichia* (*Ceratopsis*) *duftonensis*, sp. nov. Left valve. × 10.
,, 10. Ditto. Right valve. × 10.
,, 11. Ditto, ditto. × 10.
,, 11*a*. Side-view of same. × 10.
,, 12. *Beyrichia* (*Tetradella*) *Turnbulli*, sp. nov. Left valve. × 10.
,, 12*a*. Ditto, ditto. Impression of surface of same. × 10.
,, 13. Ditto, ditto. × 10.
,, 13*a*. Ditto, ditto. Impression of surface of same. × 10.
,, 14. *Beyrichia* (*Ctenobolbina*?) *superciliata*, sp. nov. Left valve. × 10.
,, 14*a*. Ditto, ditto. Impression of surface of same. × 10.

(*To be continued.*)

IV.—Petrology and Structure of the Pyritic Field of Huelva, Spain.

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(PLATE XVIII.)

Introduction.

THE great copper-mining district of Southern Spain and Portugal has been studied by several eminent geologists, and the problems presented in the geology of the field and of its ore-deposits have given rise to conflicting opinions. The three most debated points have been the origin of the ore-deposits, the relations of the igneous rocks, and the age of the sedimentary formations. The present paper, the field-work for which was carried out during the last summer season, deals in the main with the two latter points, and the writer takes this opportunity of expressing his indebtedness to Professor W. W. Watts and to Dr. C. G. Cullis for their advice and suggestions during the subsequent petrological studies at the Imperial College of Science and Technology, London.

General Relations of the District.

The copper-belt is situated at the southern end of the Iberian meseta, a fractured tableland whose essential rocks are of Palæozoic age. The meseta received its present structure with the tectonic movements and igneous eruptions of late Carboniferous and Permian times, and is one of the old Hercynian fragments, like the Armorican Mountains, the Central Plateau of France, the Vosges, and other districts of Europe. The axes of folding trend generally east and west, and the movements were accompanied by widespread intrusions of igneous rocks, and by the formation of many of the most important ore-deposits of the peninsula. The Hercynian disturbances were closed by extensive fracturing round the present edges of the tableland, notably along its south-east border. Thus the valley of the Guadalquivir follows the line of the insinking created at this period. This great fault cuts off the old mass across the strike of the folds, and is marked by a well-defined scarp along the edge of the valley between Seville and Cordoba. The fault-line appears to pass westward from the lower Guadalquivir, along the south coast by Huelva and the mouth of the Guadiana, as far as the neighbourhood of Cape St. Vincent.[1]

Throughout Mesozoic times the area was comparatively undisturbed, but in the Eocene there commenced the great Tertiary disturbances of the Mediterranean zone, which raised the Betic Cordillera (Sierra Nevada and Serrania de Ronda) in the south-east and the Pyrenees in the north. Thus the structure of the peninsula was completed. The Tertiary earth-movements were accompanied by much igneous activity along the south-east coast, and also in the neighbourhood of Lisbon. Ore-deposition was again active during this epoch, but occurred chiefly along the Tertiary lines, the southern part of the meseta not being affected to any notable extent during these movements. Later Tertiary strata occupy detached areas which were basins of deposition in the old tableland, as well as much of the eastern and south-eastern districts. The iusunken Guadalquivir trough, which connected the Mediterranean with the Atlantic transgression, has also been filled with Tertiary and later strata. Earth-tremors are still frequently felt along the old Tertiary lines, notably along the south-east coast and in the neighbourhood of Lisbon. The recent earthquakes generally also affect the line of weakness along the Guadalquivir Valley, past Cordoba, Peñaflor, Seville, and Huelva. Such was that which occurred on December 25, 1884.[2] Our knowledge of the structure of the peninsula is chiefly due to the researches of Macpherson, which are summarized in his latest paper.[3]

Outline of Geology.

The copper-field, which extends for a distance of 80 miles through the province of Huelva into Seville Province on the east and Alemtejo (Portugal) on the west, is composed of a belt of Palæozoic slates, fringed to the south by Tertiary and recent deposits, and succeeded on the north by pre-Cambrian schists and gneisses, and by less metamorphosed Cambrian strata. The Palæozoic rocks strike east and west, and have been thrown into a series of east and west folds. All the older formations are intruded by belts of igneous rocks which follow these same lines of direction, and were contemporaneous with the development of the structure of the district.

Metamorphic and Sedimentary Rocks.

The rocks which have been mapped as pre-Cambrian are found in a belt along the northern boundary of Huelva Province, outside the limits of the ore-bearing zone. They are chiefly gneisses, with bands of hornblende-schist and of crystalline and metamorphic limestones, succeeded by less altered schists and phyllites. Cambrian schists, with quartzites and greywackes, lie to the north of and are conformable

[1] E. Suess, *Das Antlitz der Erde*, English translation, Oxford, 1906, vol. ii, p. 124.

[2] Bol. Com. Map. Geol. Esp., Madrid, 1891, vol. xvii, pp. 241 et seqq. Salvador Calderon, "Movimientos pliocenicos y post-pliocenicos en el valle del Guadalquivir": An. Soc. Esp. Hist. Nat., Madrid, 1893, vol. xxii, p. 5. J. Gonzalo y Tarin, "Descripcion fisica, geologica, y minera de la provincia de Huelva": Mem. Com. Map. Geol. Esp., Madrid, 1886, vol. i, pp. 241–52.

[3] José Macpherson, "Ensayo de historia evolutiva de la peninsula iberica": An. Soc. Esp. Hist. Nat., 1902, vol. xxx, pp. 123–65.

with the upper members of the crystalline series, and are widely developed in the adjoining provinces of Badajoz and Cordoba. A belt of undoubted Silurian rocks, unconformable to the Cambrian, also occurs in the northern district. In these have been found graptolites, including *Monograptus Nilssoni* (Barr.), *M. latus* (McCoy), *M. linnæi* (Barr.), and *M. convolutus* (Hisinger),[1] as well as the so-called nereites,[2] identical with forms found in the French Pyrenees.[3]

In the slates of the mining belt to the south, similar nereites were found at Santo Domingo Mine in Portugal, at Lagunazo near Tharsis, and elsewhere. On this basis, on supposed lithological differences, and on the results of the researches of J. F. N. Delgado in Portugal,[4] a large area of the slates of the mineral zone was mapped as Silurian by the Spanish Survey. The rocks, however, contain no graptolites like those in the north, the lithological differences are insufficient to be of any value, and no unconformity can be detected between these rocks and the Carboniferous strata which compose the rest of the district. Further, since that date, the belief that the so-called nereites represent true fossils has been much discounted, and it is noteworthy that Delgado now places the nereite-bearing phyllites of Portugal in the Devonian.[5] Finally, the writer obtained a number of well-preserved specimens of *Posidonomya becheri*, the fossil found in the rocks of the district which are mapped as Carboniferous, in so-called Silurian rocks at the mine of Cabezas del Pasto, in Huelva, near the Portuguese border. All the evidence available, therefore, tends to show that the rocks throughout the mining district belong only to one period.

These rocks in general are quartz schists, phyllites, and thin-bedded slates, with bands of greywacke and quartzite, and, more rarely, limestones. A rapid alternation of greywackes and slates is frequently seen, as in the west of the province, at La Laja on the Guadiana, and in the Tharsis district. The strike of this sedimentary series is remarkably uniform throughout the field, approximating to W. 15° N. The rocks generally dip, at a varying angle, towards the north. They are fossiliferous at several localities round Rio Tinto, the slates near the Marismilla dam on the road to Nerva, and also adjoining the Bessemer plant, yielding good fossils. The following forms have been described by Lucas Mallada[6]: *Goniatites sphæricus*, *Posidonomya becheri*, *P. lateralis*, *P. gonzaloi*, *P. edmondia* (?), *P. constricta*, *P. barroisi*, and others. Several of these species, including

[1] Gonzalo y Tarin, loc. cit. sup., vol. i, p. 405.

[2] Ibid., p. 395.

[3] Ch. Barrois, "Sur les ardoises à néreites de Bourg d'Oueil (Hte.-Garonne)": Ann. Soc. Géol. du Nord, 1884, vol. xi, p. 219.

[4] J. F. N. Delgado, "Sobre a existencia do terreno siluriano no Baixo Alemtejo": Jorn. Sci. Math. Phys. e Nat., Lisbon, 1878, vol. v, pt. ii; and "Correspondance relative à la classification des schistes siluriens à néreites découverts dans le sud du Portugal": ibid., 1880, vol. vii, p. 103.

[5] J. F. N. Delgado, "Système silurique du Portugal": Commission du Service Géologique du Portugal, Lisbon, 1908, pp. 10 and 223. J. F. N. Delgado and P. Choffat, "La carte géologique du Portugal": Congrès Géol. Internat., sess. viii, 1900; Paris, 1901, p. 743.

[6] "Descripcion fisica, geologica, y minera de la provincia de Huelva": Mem. Com. Map. Geol. Esp., 1886, vol. i, p. 663.

chiefly *Posidonomya becheri*, were secured by the writer, as already mentioned, in slates near the lode of Cabezas del Pasto, in the west of the province. As regards the age of these rocks, Joaquin Gonzalo y Tarin, in his memoir on Huelva Province quoted above, places them in the Culm (Lower Carboniferous), while F. Römer[1] and R. Wimmer[2] both held the same view, and this is endorsed in recent work by F. Klockmann[3] and by Bruno Wetzig.[4] On the other hand, J. H. Collins states that Fraas and Etheridge both concluded the rocks around Rio Tinto to be of Devonian age.[5] The only rocks, however, mapped as Devonian by the Spanish Survey are some local occurrences in the provinces of Badajoz and Cordoba, north and west of the present district.[6] The bulk of the evidence, therefore, goes to support the conclusion that the rocks of the copper-belt of Huelva belong to the Culm, although the adjoining rocks in Portugal are now regarded by J. F. N. Delgado[7] as Devonian. In any case, there is nothing to show that they belong to more than one epoch, as has previously been emphasized by Klockmann[8] and by J. H. L. Vogt.[9] A small patch of Triassic limestones at Ayamonte in the south-west of the province, and a coastal belt of Tertiary and Quaternary strata, complete the geological column in this district.

Igneous Rocks.

These form an important series, not only as constituting a defined petrographic province, but also in the relation that their natural history bears to the origin of the lodes. They are distributed in belts parallel to the strike and to the axes of folding of the slates, and may be divided, for purposes of description, into three groups—the granites, the porphyries, and the basic group.

1. *Granites.*—These occur as a series of intrusive bosses in the older rocks in the north of the province, and as far south as the Concepcion Mine, and Campo Frio, near Rio Tinto, where they are intrusive into the Culm slates. On the whole, however, they are not developed in the mineral belt itself. They are evidently contemporaneous with the granitic rocks in other parts of the meseta, and form a part of the widespread series of plutonic intrusions accompanying the Hercynian earth-movements.

[1] "Über das vorkommen von Culm-schichten mit *Posidonomya becheri* auf dem Südabhange der Sierra Morena in der Provinz Huelva": Zeits. deutsch. geol. Ges., 1872, vol. xxiv, p. 589.

[2] "Die Kieslagerstätten des südlichen Spaniens und Portugals": Berg- u. Hüttenm. Zeit., 1883, vol. xlii, p. 327.

[3] "Ueber das auftreten und die entstehung der südspanischen Kieslagerstätten": Zeits. prakt. Geol., 1902, vol. x, p. 113.

[4] "Beiträge zur Kenntniss der Huelvaner Kieslagerstätten": ibid., 1906, vol. xiv, p. 173.

[5] J. H. Collins, "Geology of the Rio Tinto Mines": Quart. Journ. Geol. Soc., 1885, vol. xli, p. 246.

[6] Lucas Mallada, "Explicacion del mapa geologico de España": Mem. Com. Map. Geol. Esp., Madrid, 1898, vol. iii, p. 85.

[7] Loc. cit. sup.

[8] Loc. cit. sup.

[9] "Das Huelva-Kiesfeld in süd-Spanien und dem angrenzenden Theile von Portugal": Zeits. prakt. Geol., 1899, vol. vii, p. 241.

Petrologically, the most common type is a hornblende-granite, but the rocks vary from muscovite- and biotite-granites, through hornblende-granite and syenites, to granodiorites. Monzonite and tonalite also occur among them, considerable variation being shown in individual bosses.

2. *Porphyries.*—These rocks are very abundant both in the northern district of older rocks and in the mineral belt. In the former area they generally occur as marginal phases of the more deep-seated granite members, and also as later dykes intrusive into these. In the mining-field they frequently occur alongside the lodes, and owing to their profusion lodes are seldom found at a great distance from them.

The rocks show considerable variety, ranging, like the granitic rocks, from acid to intermediate types, with some alkaline phases. The most common type is probably a quartz-porphyry or rhyolite-porphyry, which is well developed at Rio Tinto (Pl. XVIII, Fig. 1). This rock contains abundant coarse phenocrysts of quartz, often corroded, and with inclusions of the felsitic ground-mass. The felspars are chiefly orthoclase and albite, but do not occur as phenocrysts in the more acid members. Subordinate muscovite and biotite are generally represented by chlorite and other alteration products. The ground-mass is felsitic or cryptocrystalline, and frequently contains abundant coarser grains of quartz. At times micropegmatites of quartz and albite occur, and the rocks become granophyric quartz-porphyries. With an increase in albite and microcline, quartz-keratophyres occur as local phases of the porphyries at Rio Tinto and elsewhere (Pl. XVIII, Fig. 2). A coarser-grained eurite, containing orthoclase and quartz, was observed near El Cerro, on the railway-line from Huelva to Zafra. Larger masses, such as occur in the neighbourhood of the Sotiel Mines, are typically granite-porphyries.

In the less acid members quartz phenocrysts disappear, the rocks as a rule are coarser, and include orthophyre or trachyte-porphyry, syenite-porphyry, and monzonite-porphyry. Such rocks occur north of the Tharsis Mine, at Sotiel, and elsewhere. Micrographic inter-growths are absent, and green hornblende is sometimes present, while the felspars are chiefly oligoclase and andesine.

As a rule the porphyries are found as sills and sheets, while the larger masses form bosses. In all cases, however, like the granites, they are disposed in belts parallel to the trend of the older sedimentary rocks. Owing partly to intense dynamic metamorphism of later date, contact effects are not well marked adjoining them, and mineralogical alteration of the slates can seldom be detected. The most usual evidences of intrusion are the presence of bands of porcellanite along the margins of the porphyries, and the occurrence of inclusions of baked slate.

Since their intrusion this series of rocks has been subjected to profound dynamic metamorphism. This is marked by straining and granulation of the quartzes, by crushing and complete sericitization of the felspars, and by the conversion of the ground-mass into an aggregate of quartz and finely divided sericite. Colourless epidote is often abundant as an alteration product of the felspars. Micropegmatites show complete sericitization of felspar, leaving the quartz unaltered. Included portions of the ground-mass in quartz phenocrysts are also commonly preserved from the alteration which has affected the rest of the rock. Along the margins of the intrusions dynamic effects are particularly marked. Here the porphyries have frequently been converted to highly cleaved rocks with a greasy lustre. Under the microscope these show the same mineralogical changes as the more massive porphyries, carried to a greater extreme, while the effect of pressure has resulted in perfect schistosity, marked by folia of felted sericite (Fig. 3), which enclose granulated crystals of quartz and occasional aggregates of sericite and epidote representing altered felspars. As indicating the origin of these foliated types, it is significant that they correspond, in the nature of their phenocrysts, in each case with the adjoining massive porphyries. The coarser and more porphyritic rocks are accompanied by brecciated rather than foliated modifications, in which the crystals are arranged in a broken confused aggregate, which is, in the hand-specimen, with difficulty distinguishable from a pyroclastic rock. The absence of foreign constituents, however, and the remarkable uniformity of these cleaved and crushed types, as well as their microscopic structure and relations to the less altered porphyries, indicate that their present structure is the result of pressure and movement.

The age and relations of this series of rocks have been considerably discussed. Most of the geologists who have examined them, including J. H. Collins,[1] Gonzalo y Tarin,[2] L. de Launay,[3] and J. H. L. Vogt,[4] have regarded them as intrusive into the slates. The highly cleaved marginal phases were considered by Collins to be the result of pressure during solidification, by Tarin as effects of contact-metamorphism, and by Vogt as due to subsequent pressure and shearing. On the other hand, F. Klockmann has maintained, after considerable investigation, that the porphyries are subaqueous lava-flows contemporaneous with the deposition of the slates, and that the foliated and cleaved rocks associated with them are tuffs and ash-beds, which have been subsequently sheared.[5]

The present writer's conclusions, after the examination of a large series of exposures and of collected specimens from various parts of the district, are in agreement with those of Vogt and opposed to the views of Klockmann. The chief reasons for concluding that the porphyries are intrusive, and that the cleaved varieties are due to later pressure and movement, are as follows:—

(1) The occurrence of micrographic intergrowths and of corroded

[1] "Geology of the Rio Tinto Mines": Q.J.G.S., 1885, vol. xli, p. 245.

[2] "Descripcion fisica, geologica, y minera de la provincia de Huelva": Mem. Com. Map. Geol. Esp., Madrid, 1886, vol. i.

[3] "Mémoire sur l'industrie du cuivre dans la région d'Huelva": Ann. d. Mines, 1889, ser. VIII, vol. xvi, p. 407.

[4] "Das Huelva-Kiesfeld in süd-Spanien und dem angrenzenden Theile von Portugal": Zeits. prakt. Geol., 1899, vol. vii, p. 241.

[5] F. Klockmann, "Über die lagerartige Natur der Kiesvorkommen des südlichen Spaniens und Portugals": Sitzungsber. d. preuss. Akad. d. Wissensch., Berlin, 1894, vol. xlvi, p. 1173; and "Ueber das auftreten und die entstehung der süd-spanischen Kieslagerstätten": Zeits. prakt. Geol., 1902, vol. x, p. 113.

quartz phenocrysts with inclusions of ground-mass indicates hypabyssal rather than volcanic rocks.

(2) In a single exposure of porphyry the texture is frequently found to vary from coarse to fine in passing from the centre to the edge of the mass.

(3) Intrusion is indicated by porcellanous margins and by the presence of inclusions of slate, which have been caught up in the porphyries.

(4) In some cases an examination of the line of contact showed that it crossed the bedding of the slates, and that a later cleavage had been developed in the slates parallel to this line of contact.

(5) The occurrence of fine-grained porphyries as marginal phases of the granites in places is opposed to the view that they are lava-flows, as is also the occurrence of exactly similar porphyries in rocks of Silurian and Cambrian age in the north of the province.

(6) The close correspondence of the cleaved varieties with the associated massive porphyries in each case, the great uniformity of the cleaved types, and the absence in them of foreign constituents, all go to show that they are not of pyroclastic origin.

It is therefore concluded that the porphyries are intrusive into the slates, and that since their intrusion they have been affected by intense pressure, which has given rise to shearing along the lines of contact with the slates, which were naturally lines of weakness. To this shearing has been due the development of the cleaved and foliated varieties of porphyry. If this is the correct interpretation—and all the evidence gathered in the present work goes to show that it is—then the porphyries must, from their petrological analogy to and frequent association with the granitic rocks, belong to the same stage of igneous activity as these, but to a less deep-seated phase of consolidation. They were therefore intruded along with the plutonic masses during the disturbances of the Hercynian epoch. At the same time, the intrusions were probably spread over a considerable interval, as dykes of granophyre and felsite occur in places intrusive into the granites.

3. *Basic Intrusions.*—These have a similar distribution to the porphyries, but are less abundant. In the rocks of the mining field they occur generally as sills and occasionally as bosses. They include diabases, augite-porphyrites, dolerites, and augite-diorites. Augite is very abundant and generally ophitic in habit. The rocks have, as a rule, a high titanium content, marked by ilmenite, by pleochroic augite, and by abundant perovskite. The felspars vary from andesine to anorthite, brown hornblende is occasionally present, and olivine very rarely. The adjoining contact-altered slates show the development of, first, chlorite, and finally, abundant yellowish-brown epidote.

That this basic group, whose members appear from their generally close mineralogical resemblance to be all of the same age, is the youngest of the series of igneous rocks in the district, is indicated by the fact that they are found in places intrusive into both granites and porphyries, while they have been also intruded into the Triassic rocks at Ayamonte. Further, they are unaffected by the cleavage and shearing seen in the porphyries, and the epidotization of the adjoining slates is subsequent to the sericitization of the slates which accompanied the development of cleavage throughout the area. The basic rocks must therefore have been intruded towards the end of the series of movements which has affected the district, and a considerable time-interval has clearly separated them from the older granites and porphyries.

Structure.

The slates of the area show a very uniform east-and-west strike, while the dip is generally to the north at a varying angle. This alignment is preserved in the associated igneous rocks. In the absence of folding or of overthrusting, there would be a very great thickness of rocks to account for between the coastal district and the northern metamorphic complex. In the absence of fossiliferous horizons, or of strata with a persistent lithological character, the structure of the district is difficult to unravel. The observed facts, however, suggest the presence of a series of inclined isoclinal folds, which have been followed, further, by overthrusting along the limbs of the folds, more especially in the neighbourhood of the junctions of porphyry and slate. These junctions have clearly in many cases been lines of movement, as indicated by the marginal phases of cleaved and brecciated porphyry. Further, the lode-zones also invariably occupy lines of structural weakness. Thus many lodes occur at the junction of slate and porphyry, some at the junction of slate and diabase, and the majority are contained in belts of crushed or sheared slate, enclosed between more resistent sills of porphyry or bands of greywacke or quartzite. The persistent lenticular form of the lodes also indicates that they occupy zones of fault-slipping. The shearing and faulting along the present lode-zones was, however, distinctly later than the folding of the rocks and the development of cleavage in them, since it involves the basic intrusions, and since breccias along the lode-walls, cemented by ore, are seen to contain fragments of previously cleaved and sericitized slate and porphyry. These thrust-movements, which preceded the deposition of the ores, were, therefore, the last of the series of Hercynian disturbances in the district.

Conclusions.

The general sequence of events in the area during the Hercynian epoch of crust-movement appears to have been as follows: The deposition of the Lower Carboniferous strata was succeeded by elevation and folding of the rocks, the forces acting along north and south lines, probably towards the north. With the inception of pressure came intrusions of granitic and porphyritic rocks, varying from acid to intermediate, throughout the stressed area. Further pressure after these intrusions resulted in cleavage of the slates and considerable dynamic alteration of the porphyries, especially along their margins, where they offered least resistance. After an interval of rest there was a renewal of sub-crustal forces, expressed first by the intrusion of basic rocks over the same area, and then by further pressure which resulted in shearing and probably overthrusting along zones of weakness. The deposition of the ores immediately followed these last movements, the lodes being formed in the zones of sheared or shattered rock.

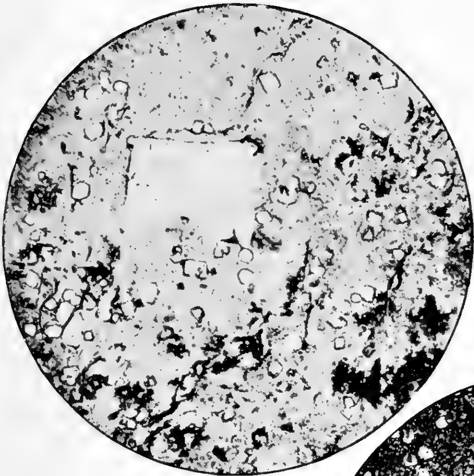
The district affords a good illustration of two features. In the first place, the development, by magmatic differentiation, of the series of igneous rocks has been closely connected with the earth-movements which have given the area its present structure. The igneous rocks and the tectonic structure are coextensive, and the magmatic differentiation has doubtless been attendant on the sub-crustal stresses of the Hercynian epoch. In the second place, the relation of the ore-deposits to the igneous rocks is, broadly speaking, a genetic one. The defined petrographic province, limited to a certain area, is accompanied by the equally defined group of pyritic ore-bodies, limited to practically the same area. In other words, there is here a metallogenetic province accompanied by a corresponding petrographic province. The association indicates the close dependence of ore-formation on earth-stresses and magmatic processes. While there is nothing to show that the lodes are genetically related to one particular group of igneous rocks, there is strong reason for believing that the concentration of the sulphides has been primarily a magmatic process, intimately bound up with the progressive differentiation which resulted in the igneous rocks now exposed. The ore-deposits, in short, represent the final product of the magmatic processes, just as the fault-zones in which the lodes occur were the last result of the earth-movements with which these magmatic processes were involved.

The Huelva copper-field is closely paralleled in almost every respect by the Avoca district in co. Wicklow.[1] Here a belt of Palæozoic slates is succeeded to the west by the Leinster granite massif, and the slates are intruded by a series of abundant sills and dykes of both acid and basic rocks, in part contemporaneous with and in part later than the granite. These intrusions have been intensely altered by subsequent pressure and movement,[2] and, as in the Huelva district, there is a general parallelism in the strike of the slates and in the alignment of both the granite and the abundant smaller intrusions. Finally, there occurs in the slates, and on the same general trend, a belt of pyritic lodes, sometimes enclosed in slate and sometimes adjoining sills of felsite or greenstone, but always in zones of shearing and crushing. Both structurally and mineralogically the ore-bodies of Avoca and those of Huelva show exactly the same features. Specimens of ore from the two fields are indistinguishable under the microscope. It is clear that in both districts similar agencies have been at work, with the production of exactly similar results.

EXPLANATION OF PLATE XVIII.

Fig. 1. *Rhyolite-porphyry*, Rio Tinto. The specimen contains quartz phenocrysts and abundant smaller grains of quartz, embedded in a felsitic or cryptocrystalline matrix, which has been largely converted to sericite. The rock is impregnated with pyrite and somewhat sheared. × 36.

[1] Explan. Sheets 138 and 139, Geol. Surv. Ireland, 1888.
[2] Sum. Prog. for 1900, Geol. Surv. Great Britain, p. 51.



1

2

3

Porphyries, Huelva, Spain : (1) Rio Tinto, (2) Tharsis, (3) Sotiel.

FIG. 2. *Trachyte-porphyry* (near keratophyre), Tharsis. Contains phenocrysts of orthoclase, albite, and corroded quartz. The ground-mass is a felt of very fine felspar laths with abundant coarser quartz grains. × 36.

FIG. 3. *Sheared porphyry*, Sotiel. Quartz phenocrysts have been crushed and granulated, felspars have been converted to aggregates of sericite fibres, and the ground-mass to a very fine felt of quartz and sericite, with a highly developed schistosity. × 36.

V.—ORGANIC REMAINS IN THE TRIAS OF NOTTINGHAM.

By H. H. SWINNERTON, D.Sc., F.G.S., F.Z.S.

THE city of Nottingham is built upon the outcrop of the Trias. Building and road-making operations consequent upon its rapid growth often lead to the laying bare of the underlying Bunter, Keuper Waterstones and Marls. Unfortunately the work is usually carried on with such rapidity that good exposures are often missed. A temporary cessation of activities in one part of the Sherwood suburb, however, left a beautiful exposure of the Waterstones. A careful examination of this during the past few months has led to the discovery of footprints and fish-remains. The footprints are of a type which does not seem to fit into the generally used system of classification. In 1857 the Rev. A. Irving found a Cheirotheroid print in the railway cutting at Colwick. This is the only record of the previous discovery of footprints in this district.

Well-preserved remains of fish (*Semionotus*) are fairly common in one layer of light-coloured sandstone only 2½ inches thick. The upper surface of this is partly covered with small, ill-defined ripple-marks. The fish seem to have been left stranded upon this, and in their struggles to escape have made depressions and become buried in the sand they stirred up. The remains are buried in lenticular pieces of sandstone which can be lifted bodily out of the depressions. These vary in size from a few inches across to a couple of feet. The horizon at which they occur is evidently higher than that at which similar remains were found by Edward Wilson at Colwick in 1879.

The scales, fin-rays, and some bones are often perfectly preserved, but being embedded in sandstone they have to be dissected out with great care. As this is a tedious process, it seemed advisable to announce the find without delay.

REVIEWS.

THE COAL BASIN OF COMMENTRY IN CENTRAL FRANCE.

THIS is the title of a paper by Mr. J. J. Stevenson (Ann. New York Acad. Sci., xix, p. 161, February, 1910). The basin was described in 1887 by Henri Fayol as about 9 kilometres long, 3 kilometres wide, and 700 metres deep; and it is isolated from two other small basins mainly by granite, the basins having been separated just prior to the time of the Coal-measures. Thus the deposits were always distinct, a conclusion formed by De Launay and confirmed by Fayol. The most important contention of Fayol was that the coal-seams were formed, not in situ, but by transport; and to study this question Mr. Stevenson paid a special visit to examine the enormous excavations that have been made in mining the coal by stripping.

The Lower Coal-measures are formed almost wholly of rather coarse materials, with some unimportant lenticles of anthracite; the Middle Coal-measures consist chiefly of fine materials, and include the great coal-beds—mainly a single bed, the *Grande Couche*, 30 to 60 feet thick, but divided into two or more seams in a westerly direction; the Upper Coal-measures comprise more or less coarse detritus, and practically contain no coal.

The strata have a dip of about 30°, and this has been supposed to be the original slope of the beds. Fayol conceived that the strata were deposited in accordance with their specific gravity, the plant debris forming the beds of coal. Mr. Stevenson remarks that when one considers the enormous mass of the Grande Couche, not less than 30,000,000 cubic metres, it is difficult to realize that it could have been formed from such vegetable matter as could have been washed in from an area of about 26 square miles; and he maintains that the form and variations of the Grande Couche leave little room for doubt that the bed represents plants which grew where the coal now is. The marsh-vegetation consisted of *Cordaites* trees, with a dense growth of ferns, lepidodendra, and other plants; and the sandy clay underlying the Grande Couche, crowded with vegetable remains, is clayey enough to have prevented downward drainage.

Evidence is brought forward to show that the strata were exposed to tremendous pressure after consolidation. Occasionally the coal itself is crushed into small lenticles, which have been rubbed and polished. The author concludes that a differential subsidence, combined with the effect of compression and carbonization, would account for the high dips, which have been regarded as original.

Mr. Stevenson promises to publish a monograph on the formation of coal-beds. In the present communication he has not considered that the quiet, undisturbed condition of the organic remains, both plants and animals, so abundant in the coal-shales of Commentry, offered the best and most complete refutation of M. Henri Fayol's theory of the transportation and redeposition of the materials of these coal-beds in their present resting-place.

A reference to the great work by M. Chas. Brongniart on the wonderful insect fauna of Commentry would show how abundant and well preserved are the remains of these delicate and beautiful winged organisms.[1] Whilst in Europe and North America there have been described about 120 examples, at Commentry alone, since 1878, 1300 have been met with, of which the greater part is admirably preserved.[2]

After sixteen years of continuous labour, mostly devoted to the insect fauna of Commentry, M. Chas. Brongniart brought out his great work *Histoire des Insectes Fossiles des temps primaires* (Ste. Etienne,

[1] See Geol. Mag., 1879, pp. 97–102, *Protophasma Dumasii*, Ch. Br.
[2] Ibid., 1885, pp. 481–91, Pl. XII, *Woodwardia*, *Caloneura*, *Corydaloides*, etc.

1893, 4to, pp. 496; and Atlas, 4to, pp. 44 and plates 53, many of which are double or folding).

"It has been reserved [says his reviewer[1]] to one favoured locality in a circumscribed area of Central France [Commentry] to furnish more specimens of fossil insects and in a better and more complete condition than in all the previously known localities of the world put together." It may be of interest to record here that Dr. Brongniart discovered at Commentry the largest Dragon-fly known (*Meganeura Monyi*), measuring 28 inches in the spread of its wings.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

March 9, 1910.—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 1910 to Mr. Robert Boyle, B.Sc., who proposes to make a series of researches on the Carboniferous Building-stones of Scotland.

The following communication was read:—

"The Carboniferous Succession in Gower (Glamorganshire)." By Ernest Edward Leslie Dixon, B.Sc., F.G.S., and Arthur Vaughan, B.A., D.Sc., F.G.S.

The succession in three districts in Gower is described, the districts being so situated that a comparison of their respective developments can be interpreted in the light of the fact that, during Avonian time, the nearest coast lay to the north, with a general east-and-west trend. With the description of the lithological sequence are included notes on some breccia-like limestones, characteristic of D, and on 'lagoon-phases' and the origin of radiolarian cherts. To the faunal lists are added notes on the D_2–D_3 phase of the *Dibunophyllum*-zone, which distinguishes Gower from the rest of the South-Western Province at present known, and on the correlation of that zone with the Upper Bernician of Northumberland. From the faunal sequence it is concluded that the zones Z, C, S, D_1, and D_2 (the K Zone is poorly exposed) are characterized by the same assemblages as in the Bristol area.

The lithological sequence shows (1) that over the whole area the depth of the Carboniferous sea underwent a complete cycle of intermittent change during Lower Avonian time, the initial deepening being followed by gradual shallowing up to the top of the lower part, C_1, of the *Syringothyris*-zone, which was deposited almost at sea-level; (2) that a similar cycle marked the ensuing period up to the top of the *Seminula*-zone; (3) that a similar but smaller cycle took place in the *Dibunophyllum*-zone, the latter actually reaching the surface; and (4) that a fourth cycle, commencing with a far-reaching physiographic change, characterized the *Posidonomya*-zone.

Further, a comparison of the sequences and thicknesses in the three

[1] Geol. Mag., 1895, pp. 233–6.

districts shows that, not only were the downward movements of the sea-bottom during the first two cycles greater in the south than in the north, but also that the axis on which the movement during the first cycle hinged was different in direction from the axis during the second cycle. The bearing of these movements on the question of the delimitation of the divisions of the Avonian is then discussed. They suggest that the base of the upper part, C_2, of the *Syringothyris*-zone should form the base of the Upper Avonian. On the other hand, the base of C_2 in at least two localities is closely connected, faunally, with the zones below, whereas the fauna of the main mass of C_2 passes into S_1 without appreciable change other than the introduction of *Lithostrotion*. It will, therefore, in all probability be decided that the break between the Lower and the Upper Avonian should be taken at a level within C rather than at the base of the *Seminula*-zone. For the present, however, this question must be deferred, since it concerns the whole extent of the formation in Belgium, the North of France, and the British Isles.

The paper concludes with notes on some of the corals and Brachiopods, including one new species of coral and two new species and a new variety of Brachiopod.

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

The President referred in sympathetic terms to the recent decease, at the age of 98, of Prebendary William Henry Egerton, who had been a Fellow of the Society since 1832.

The following communication was read:—

"On *Palæoxyris* and other Allied Fossils from the Derbyshire and Nottinghamshire Coalfield." By Lewis Moysey, B.A., M.B., B.C., F.G.S.

After reviewing the bibliography of *Palæoxyris*, the author records the finding of twenty-two specimens from Shipley Clay-pit (Derbyshire), and over 130 from Digby Clay-pit (Nottinghamshire), also several isolated examples from other localities in the district.

He describes *P. helicteroides* (Morris), noting especially the presence of a 'beak', which had not hitherto been adequately described. He then describes *P. prendeli* (Lesquereux) from Shipley Clay-pit, again noticing the formation of the 'beak'. The discovery of *P. Johnsoni* (Kidston) from Digby is noted, and it is proposed that this fossil be removed into the genus *Vetacapsula*.

The author also describes a specimen of *V. Cooperi* (Mackie & Crocker) from Newthorpe Clay-pit (Nottinghamshire). He discusses the differences between this and other specimens, and Mackie's type-specimen, but considers it unadvisable to multiply species.

A review of the bibliography of *Fayolia* is followed by the description of a new species from Shipley Clay-pit; also a small compressed example is described as near to *F. dentata* (Renault & Zeiller). The author then discusses the distribution of these organisms in time, and their possible affinities with the egg-capsules of the Cestracionts and the Chimæroids.

II.—Mineralogical Society.

March 15, 1910.—Professor W. J. Lewis, F.R.S., in the Chair.

G. W. Grabham: A new form of Petrological Microscope, with notes on the illumination of microscopic objects. The new instrument, which is of the 'Dick' or 'English' pattern, has a focussing sub-stage carrying a series of condensers mounted on a triple nose-piece, each capable of being inserted in the axis of the instrument. A new explanation was given of the 'Becke' or bright-line effect, especially applicable to parallel polarized light traversing mineral sections which meet along inclined junctions.—W. F. P. McLintock: On Datolite from the Lizard District. Datolite, which is associated with calcite, chalcopyrite, and natrolite (rare) in veins and geodes at the junction of the serpentine and hornblende schist, Parc Bean Cove, Mullion, Lizard District, Cornwall, occurs in crystals measuring up to 2 cm. along the *b* axis, and displayed fourteen forms, of which two were new. An analysis gave SiO_2 37·45, CaO 34·67, Fe_2O_3 and Al_2O_3 0·57, B_2O_3 21·87, H_2O 5·67; total 100·23.—Arthur Russell: Additional notes on the occurrence of Zoolites in Cornwall and Devon. The occurrence of heulandite, a mineral hitherto not recorded from Cornwall, at Carrick Du Mine, St. Ives, Cornwall, was described; also of chabazite and heulandite at the Ramsley Mine, South Tawton, Devon.—Dr. J. W. Evans: A modification of Stereographic Projection. Faces below the plane of projection are represented by the same points as parallel faces above it, upper faces being distinguished by a plus and lower faces by a minus sign.—Dr. J. W. Evans: Axes of Rotatory Symmetry. Coincidence is complete or codirectional when equivalent lines and their directions coincide, incomplete or contradirectional when equivalent lines coincide, but equivalent directions of uniterminal lines are opposed; in both cases it is colinear. If a minimum rotation of $\frac{2\pi}{n}$ result in codirectional, contradirectional, or colinear coincidence, the axis of rotation has codirectional, contradirectional, or colinear symmetry, with cyclic number n.—Professor H. L. Bowman exhibited models illustrating space-lattices and Sohncke's point-systems.

CORRESPONDENCE.

THE USE OF THE TERMS 'LATERITE' AND 'BAUXITE'.

Sir,—Mr. Scrivenor's further remarks on this subject in the March number of the Geological Magazine, replying to mine in the number for November last, bring into sharp relief some of the difficulties which he and others experience with regard to the recognition and use of 'laterite' as a scientific term. I for one am not unaware of these difficulties. Indeed, I perceive one or two which are in my opinion more serious than those mentioned by Mr. Scrivenor. At the same time, all these difficulties taken together are small compared with those which prevent us from adopting the use of the mineralogical term 'bauxite' as a rock name. Furthermore, surely the fact that some engineers—and, alas! some others—have abused the term laterite, is not a sound reason why geologists should relinquish their use of it in a scientific sense, especially when, as I pointed out in my previous letter, such a use can be shown to be quite consistent with the original meaning of the term.

Mr. Scrivenor now admits the inaccuracy involved in the unrestricted use of the term laterite for ferruginous surface products. He seems not to be aware, however, that his proposal to extend the use of the term bauxite is equally objectionable. His only remedy for the abuse of the word laterite is a still further abuse of the word bauxite, a course of procedure in which I confess inability to see any wisdom at all, practical or otherwise. Unfortunately, the term bauxite has been so carelessly used by most writers, that there is some degree of plausibility in his suggestion.

Now I fully admit that bauxite is a mineralogical uncertainty; and that there may not be a definite mineral corresponding in composition to the formula $Al_2 O_3 2 H_2 O$, which has always been attributed to bauxite by mineralogists; but until this possible fact has been definitely established and accepted by mineralogists, it seems to me that bauxite must remain a mineralogical name which cannot be applied indiscriminately by scientific workers to lateritic weathering products.

Is Mr. Scrivenor aware of the fact that the use of the term bauxite in a petrographical sense, for a mixture of hydrated oxides and other substances, would invalidate its use as a simple mineral name? If so, dare he assert, in view of the proved existence of xanthosiderite ($Fe_2O_3 2 H_2O$), that its aluminium analogue, the bauxite of mineralogy, does not exist? If not, what name does he propose to give to the possible $Al_2 O_3 2 H_2 O$ of mineralogy?

If it be ultimately proved that the mineral bauxite ($Al_2 O_3 2 H_2 O$) does not exist, and that the material which has hitherto been regarded as such is really and always a mixture of gibbsite ($Al_2 O_3 3 H_2 O$) and diaspore ($Al_2 O_3 H_2 O$), it will then be necessary for mineralogists to abandon bauxite as a simple mineral name; and in that event it will possibly be available for petrographical use. If on the other hand, as is more likely to be the case, mineralogists decide that there is a definite mineral corresponding in composition to the formula $Al_2 O_3 2 H_2 O$, then the name bauxite will unquestionably belong to this substance, and this alone, in scientific nomenclature; that is, if Mr. Scrivenor and others fail, as I hope they will, in their efforts to degrade the word bauxite completely. This issue would more than ever leave a large and important function for the word laterite as a petrographical term. It is this scientific necessity of making provision for $Al_2 O_3 2 H_2 O$, the bauxite of mineralogy, which makes Mr. Scrivenor's suggestion positively harmful, and puts an insuperable difficulty in the way of its adoption by geologists.

Anent the rather misleading statement by Mr. Scrivenor, that "in other countries the original definition [of laterite] has been abandoned", I can only repeat the fact that the authorities of the present generation who have gone seriously into the study of laterite are at one as regards the scientific meaning to be attached to the term. The French and German schools from their study of African deposits, and most important of all the officials of the Geological Survey of India who have to deal with the type occurrences, are all agreed as to the desirability of retaining the use of the term 'laterite' in much the same sense as I have defined it. The only culprits appear to be those who have either ignored the drift of recent tendencies in this matter, or who have preferred to attach more importance to the vulgar than to the scientific use of the term.

In conclusion, I fail to see any good reason why both laterite and bauxite should not be regarded as very useful scientific terms, the former more particularly for petrographical, the latter for mineralogical purposes.

T. Crook.

Scientific Department, Imperial Institute, S.W.

Geology of Bodmin and St. Austell.—In our review of the Geological Survey Memoir on this district (Geol. Mag., February, p. 85) we called attention to the omission from certain portions of the work of the initials of the responsible author. We are informed by Mr. D. A. MacAlister that the contributions made by the several authors to the pages of the Memoir are as follows:—

Barrow, G.: pp. 12, 27–8, 29–31, 32, 40–4, 63–4, 73–6, 83–91, 119–20, 180–1.
Flett, J. S.: pp. 44–53, 56–61, 65–8, 76–9, 93–104, 117, 8.
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OBITUARY.

CHARLES EDWARD FOX-STRANGWAYS, F.G.S.

Born February 13, 1844. Died March 5, 1910.

We have to deplore the death of Mr. C. Fox-Strangways at the age of 66. We give his name here as he wrote it, omitting the second initial.

He was born at Rewe, a village situated on the River Culm about 4½ miles north-east of Exeter. There his father, the Rev. Henry Fox-Strangways, a grandson of the first Earl of Ilchester, was Rector. Another relation, the Hon. William Thomas Horner Fox-Strangways, had become a member of the Geological Society in 1815, and had communicated papers to the Transactions of the Society on the geology of Russia, and of the neighbourhood of St. Petersburg in particular. He served on the Council of the Society in 1820–1, was elected a Fellow of the Royal Society in 1821, and eventually succeeded to the title as fourth Earl of Ilchester.

C. Fox-Strangways was educated at Eton, about the same time as his cousin, the late Sir Redvers Buller, and afterwards proceeded to the University of Göttingen, where among other subjects he studied mineralogy, chemistry, and physics. In 1866, when war was declared between Austria and Prussia, he assisted Sartorius von Waltershausen, the professor of geology and mineralogy, in burying his precious collection of minerals, so as to prevent it from falling into the hands of the belligerents. Soon after his return to England, Strangways was appointed, July 20, 1867, an Assistant Geologist on the Geological Survey, under Murchison as Director-General and Ramsay as Director. He commenced field-work on the western borders of Yorkshire near Todmorden, and was occupied for a time in surveying portions of the neighbourhood of Ingleton. Thence he worked eastwards over part of the great Yorkshire coal-field and in the country around Harrogate, across the Vale of York to the Jurassic and Cretaceous rocks of the East Yorkshire moors and wolds, residing for some years at Scarborough. Apart from the memoirs relating to these areas, which he prepared in explanation of the geological survey maps, Mr. Strangways wrote an elaborate general memoir on the Jurassic Rocks of Yorkshire.

In 1889 he was transferred to the Midland counties, and took up residence at Leicester until the close of his official career in 1904. In 1901 he had been promoted to be District Geologist when the Geological Survey was reorganized under the Directorship of Dr. J. J. H. Teall; but his retirement at the age of 60 was rendered desirable by weakness of heart, which at that time began to impede his wonted activity in the field. While at Leicester Mr. Strangways surveyed in detail the Leicestershire coal-field and prepared an important memoir on the subject; but his field-work extended over a much larger area, as indicated in the appended list of official publications. He also did a great deal to stir up local interest in geology at Leicester, in furtherance of which he planned and conducted numerous field-excursions in the district, and in 1903 and 1904 to Scarborough and Whitby, reports of which were printed in the Transactions of the Leicester Literary and Philosophical Society.

Methodical and painstaking in all his work, his accuracy and the care he took in mastering the literature on all subjects he dealt with, kept him free from the domain of controversy. It is thus interesting to mention that Professor P. F. Kendall, in his important paper on "A System of Glacier-Lakes in the Cleveland Hills" (1902), refers to "a great lake in the Vale of Pickering, postulated upon very inconclusive grounds by Phillips and other writers, but demonstrated in a very clear and convincing manner by Mr. C. Fox-Strangways".[1]

Strangways married in 1868 Annie Maria, daughter of the late George Flory of Ipswich, and had no issue. In 1873 he was elected a Fellow of the Geological Society, and served as member of Council during the years 1905–8.

He was fond of travel and had journeyed to South Africa, Canada, and the United States, and in almost every country in Europe. Spitzbergen and Iceland were visited in 1899, with his nephew Mr. A. W. Searley, who took a series of instructive photographs, some of which were published in illustration of a paper printed by Mr. Strangways in 1900.[2]

His chief publications were the numerous memoirs dealing with the geology of the districts he had surveyed; and of two of these, the

[1] Quart. Journ. Geol. Soc., vol. lviii, p. 473.

[2] We are indebted to Mr. Searley for some particulars relating to the life of his uncle.

memoirs on Harrogate and on the country south of Scarborough, he had prepared new editions within the last six years. During the past year and up to the time of his death, caused by heart-failure, he had been steadily engaged on an exhaustive geological bibliography of Yorkshire, and had practically completed this work, after many visits to the British Museum and other libraries for the purpose of seeing and verifying each record.

A staunch friend, and a man of most amiable disposition, although exceedingly reserved, his loss will long be felt personally as well as scientifically, by all acquainted with him and his works.

List of Geological Survey Memoirs.

1873. The Geology of the Country North and East of Harrogate. 2nd ed., 1908.
1878. The Geology of the Yorkshire Coal Field. (Notes contributed to Memoir by A. H. Green.)
1879. The Geology of the Country between Bradford and Skipton. (With J. R. Dakyns and others.)
1880. The Geology of the Oolitic and Cretaceous Rocks South of Scarborough. 2nd ed., 1904.
1881. The Oolitic and Liassic Rocks to the North and West of Malton.
1882. The Geology of the Country between Whitby and Scarborough. (With G. Barrow.)
1884. The Geology of the Country North-East of York and South of Malton.
1885. The Geology of Bridlington Bay. (With J. R. Dakyns.)
The Geology of Eskdale, Rosedale, etc. (With C. Reid and G. Barrow.)
1886. The Geology of the Country between York and Hull. (With J. R. Dakyns and A. C. G. Cameron.)
The Geology of the Country around Driffield. (With J. R. Dakyns.)
The Geology of the Country around Northallerton and Thirsk. (With A. C. G. Cameron and G. Barrow.)
1890. The Geology of the Country around Ingleborough. (Notes contributed to Memoir by J. R. Dakyns, R. H. Tiddeman, W. Gunn, and A. Strahan.)
The Geology of Parts of North Lincolnshire and South Yorkshire. (Notes contributed to Memoir by W. A. E. Ussher.)
1892. The Jurassic Rocks of Britain: Yorkshire. 2 vols.
1900. The Geology of the Country between Atherstone and Charnwood Forest.
1903. The Geology of the Country near Leicester.
1905. The Geology of the Country between Derby, Burton-on-Trent, Ashby-de-la-Zouch, and Loughborough.
1906. The Water Supply from Underground Sources of the East Riding of Yorkshire.
1907. The Geology of the Leicestershire and South Derbyshire Coalfield.
1908. The Geology of the Southern Part of the Derbyshire and Nottinghamshire Coalfield. (Notes contributed to Memoir by W. Gibson and others.)
1909. The Geology of the Melton Mowbray District and South-East Nottinghamshire. (Notes contributed to Memoir by G. W. Lamplugh and others.)

In addition to the various 1 inch and 6 inch geological maps, Mr. Strangways prepared a number of Horizontal Sections across the Oolitic districts of East Yorkshire which were accompanied by brief explanatory pamphlets; and also one sheet of Vertical Sections of the Oolites from Filey to Cloughton.

List of Principal Unofficial Papers.

1885. "The Harrogate Wells, or the Mineral Waters of Harrogate geologically considered": Proc. Yorks. Geol. Soc., viii, p. 318.
1894. "Dr. Alex. Brown on *Solenopora*": Geol. Mag., p. 236.
"The Valleys of North-East Yorkshire and their Mode of Formation": Trans. Leicester Lit. and Phil. Soc., iii, p. 333.

1895. "Glacial Phenomena near York": Proc. Yorks. Geol. Soc., xiii, p. 15.
1897. "Geology of the London Extension of the Manchester, Sheffield, and Lincolnshire Railway."—Part I: Annesley to Rugby: Geol. Mag., p. 49.
"Notes on the Stratigraphy of the Newer Rocks of the Netherseal Borings": Trans. Fed. Inst. M.E., xiii, p. 598.
"Notes on the Coast between Redcar and Scarborough": Proc. Yorks. Geol. Soc., xiii, p. 248.
1898. "Sections along the Lancashire, Derbyshire, and East Coast Railway between Lincoln and Chesterfield": Quart. Journ. Geol. Soc., liv, p. 157.
"Filey Bay and Brigg": Proc. Yorks. Geol. Soc., xiii, p. 338.
"Notes on the Coast Sections between Hayburn Wyke and Filey": ibid., p. 356.
1900. "Notes on Spitsbergen and Iceland": Trans. Leicester Lit. and Phil. Soc., v, p. 404.
1907. Article "Geology" in the Victoria History of the Counties of England, Leicester, vol. i.
"The Geology of North-East Yorkshire in relation to the Water Supply of the District": Trans. Brit. Assoc. Waterw. Engin., xi, p. 113.
Article "Geology" in "A Guide to Leicester and District": prepared for Brit. Assoc.
1908. "Notes on the Geology of Leicestershire": Rep. Brit. Assoc. for 1907, p. 503.

H. B. W.

ALEXANDER AGASSIZ,

For. Memb. Roy. Soc.

Born December 17, 1835. Died March 28, 1910.

We regret to record the death of this distinguished naturalist on March 28 at the age of 74, when returning from Europe to the United States on board the s.s. "Adriatic".

Born at Neuchâtel, Switzerland, December 17, 1835, son of the celebrated Professor Louis Agassiz,[1] he accompanied his father in 1846 to the United States, where the elder Agassiz had been appointed Professor of Zoology and Geology in the University of Cambridge, Massachusetts. Educated at Harvard, where he took his B.Sc. degree at the age of 22, and of which University in 1878 he was elected a Fellow, Alexander Agassiz served for a short time on the United States Geological Survey. Turning his attention shortly afterwards to mining, he speedily proved so successful that, having acquired property in the Lake Superior region, he rapidly amassed a very large fortune in copper-mines.

The possession of independent means early enabled him to devote his time and studies to natural history pursuits. At first he assisted his father as Curator of Comparative Zoology at Harvard, and after his father's death he acted as Curator for eleven years. As his wealth increased he became a great benefactor to this Museum, not only by purchasing books and specimens, but by gifts of money up to £100,000. Commencing with the study of marine ichthyology, he subsequently devoted himself to, and became one of the highest authorities on, the Echinodermata, so that, on the return of H.M.S. "Challenger", he was asked to undertake the report on the Echinoderms collected during the voyage.

But the work for which Alexander Agassiz will be chiefly

[1] See obituary of Professor L. Agassiz (1807–73), Geol. Mag., 1874, pp. 47–8.

remembered was that which, during nearly forty years, he carried on at his own expense in connexion with oceanography. The United States Government, with the greatest liberality and consideration for the interests of science, allowed him from time to time the use of their surveying vessels, the Captains of which were instructed to place themselves virtually under the orders of Agassiz himself. The naturalist, aided by a staff selected and paid by himself, carried on soundings and dredgings in every part of the globe, special attention being devoted to the study of coral reefs. Beginning in 1877 with the study of the Gulf of Mexico, the Caribbean Sea, and the Atlantic coast of America, Agassiz continued his work in 1880 by investigating the surface fauna of the Gulf Stream. Besides working out the details derived from the study of collections made during these voyages, the results of which were published in connexion with the Harvard Museum of Comparative Zoology, Agassiz wrote a well-illustrated account of his work, *The Three Voyages of the "Blake"*, in two volumes.

In 1891 Agassiz transferred his attention to the western shores of the United States and Central America, investigating the seas around the Sandwich Islands, and paying special attention to the coral reefs there, between 1892 and 1894. His explorations were extended during 1895–6 to the Great Barrier Reef of Australia, and in 1897–8 to the Fiji Islands. In 1899 and 1900 he was able to undertake a cruise among the various groups of coral islands lying between San Francisco and Japan. In 1901–2 Agassiz commenced his study of the Indian Ocean, paying especial attention to the Maldive Islands and their surroundings; and, in order to complete the examination of portions of the Pacific that he had not already visited, he devoted the years 1904–5 to a cruise among the important island-groups of the eastern half of the Pacific Ocean.

The intervals between his several voyages were occupied by Agassiz in the study of his enormous collections and the preparation of memoirs dealing with the results obtained. These were issued, regardless of expense as to their illustration, in the publications of the Boston Society's Museum of Comparative Zoology. No fewer than thirty volumes of memoirs and fifty-three volumes of bulletins are devoted to the results obtained from the study of these collections by Agassiz and the various specialists who assisted him. His own favourite place of work was Paris, where rooms were always allotted to him in the Museum of Natural History, and he had the fullest access to scientific libraries.

Of the value and importance of the results of these voyages it is impossible to speak too highly. Perhaps the most striking of the conclusions arrived at by him are those relating to great movements which have taken place in the bed of the Pacific in comparatively recent geological times. This is evidenced by the numerous upraised coral reefs which, following Dana, he described; in many of these the limestone rock, now at elevations of 1000 feet and upwards, has been more or less completely converted into dolomite.

It is not necessary, in face of the above statement of facts, to add that Agassiz was a man of indomitable energy. He thought as little of crossing the Atlantic as we do of crossing the Thames, and death met him at last while still "on the move".

In early life Alexander Agassiz exhibited something of the dogmatic habit of mind that distinguished his illustrious father; but, mellowed by age and constant intercourse with other men, he became in after life strikingly open-minded and ready to listen to arguments, even those that told against his most cherished convictions. Those who were privileged to enjoy his friendship in his later life knew him as a man of ardent enthusiasm, restless energy, and charming bonhomie, but also as one patient in discussion, and always ready to listen to facts and reasonings from whatever quarter they came. His generosity was unbounded, and he was ever willing to place his abundant materials at the service of young men who were qualified and desirous to engage in their study.

In every scientific circle of Europe, as well as in those of America, Alexander Agassiz was well known, and in all of them his loss will be deeply mourned. In France he received the Légion d'Honneur, and in Germany the Order of Merit. In this country he was since 1874 a Foreign Member of the Zoological Society, and for many years a Foreign Member of the Royal Society. Only last year the Royal Geographical Society awarded him the Victoria Research Medal, and we may fitly conclude this notice with the verdict of the President in announcing the award—a verdict in the justice of which all must agree—"He has done more for oceanographical research than any other single individual." [1]

MISCELLANEOUS.

Provence Fossil Invertebrates.—The Geological Department of the British Museum has recently acquired a further selection of the rarer Mesozoic species from the collection of Mr. A. Michalet, member of the Geological Society of France. We understand that Mr. Michalet's cabinets have become so overcrowded that he would be glad to dispose of his duplicates to any British colleagues who may desire them at a merely nominal price. His address is Allée des Platanes, Quartier de la Barre, Toulon (Var).

The Mammoth Cave, Western Australia.—In the *Records of the Western Australian Museum and Art Gallery* (vol. i, pt. i, 1910, edited by Mr. Bernard H. Woodward), there is an account of various mammalian remains obtained from this cave, and described by Mr. L. Glauert. The specimens include *Phascolomys Hacketti*, sp. nov., *Phascolarctus cinereus* (Goldf.), and *Sthenurus occidentalis*, sp. nov., which are figured.

Geologists' Association.—A most useful Classified Index to the Contents of the Proceedings of the Geologists' Association, vols. i–xx, has been compiled by Mr. G. W. Young and Mr. William Wright. It is issued as pt. vii of vol. xxi at the price of 1*s.* 6*d.*, and comprises (1) List of Papers and Lectures, under names of Authors, (2) Subject Index to Papers, (3) Index to Localities of Excursions, and (4) Chronological List of the Longer Excursions.

[1] Taken chiefly from Professor J. W. Judd's notice in *Nature*, April 7, 1910, p. 163.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VII.

No. VI.—JUNE, 1910.

HIS MOST GRACIOUS MAJESTY

KING EDWARD VII

PASSED AWAY MAY 6, 1910,

BELOVED AND MOURNED BY ALL HIS PEOPLE, AFTER A SHORT BUT STRENUOUS REIGN OF NINE YEARS, DEVOTED TO ALL GOOD WORKS IN THE BRITISH DOMINIONS AND TO THE WELL-BEING AND PEACE OF THE NATIONS.

ORIGINAL ARTICLES.

I.—Notes on a Collection of Fossil Plants from the Newent Coal-field (Gloucestershire).

By E. A. Newell Arber, M.A., F.L.S., F.G.S.

IT has been known for more than a hundred years past that a small tract of Upper Carboniferous rocks occurs in North-West Gloucestershire, between May Hill and the Malverns. The beds crop out in the neighbourhood of Newent, a village lying some ten miles to the north-west of Gloucester. The field, however, is almost entirely concealed beneath Triassic rocks. The measures are productive, and have been worked at various periods on a small scale, though the greater portion of the basin remains to this day unexplored.

The geology of the district was first studied by the celebrated William Smith, in 1803 and 1805. In his manuscript notes,[1] published in 1844, there is a section of the sinking at Boulsden, or, as it was then apparently called, 'Bowsden,' one mile south-west of Newent, where a coal-seam crops out. In the past the coal has been more extensively worked at this spot than at any other in the district.

It is not proposed to enter here into the geology of this tract of Carboniferous rocks. What is known on the subject will be found in the papers by Weaver,[2] Maclauchlan,[3] Murchison,[4] and especially in the excellent Survey memoir dealing with the district of the Malvern

[1] J. Phillips, *Memoirs of William Smith*, 1844, pp. 54, 58.
[2] T. Weaver, Trans. Geol. Soc., 1824, ser. II, vol. i, pt. ii, p. 317.
[3] H. Maclauchlan, Trans. Geol. Soc., 1837, ser. II, vol. v, pt. i, p. 203.
[4] R. I. Murchison, Proc. Geol. Soc., 1835, vol. ii, No. 38, p. 121; see also *The Silurian System*, etc., London, 1839, p. 153.

Hills by John Phillips.[1] So far as I am aware no additions have been made to our knowledge on this subject since 1848.

I have for some years past been occupied with a study of the distribution of fossil plants in the Forest of Dean, which lies roughly between the Newent and Bristol Coal-fields. The flora of the Bristol Coal-field has recently been extended and revised by my friend and former pupil Mr. Lillie.[2] My attention was thus naturally turned to the Newent tract, and after some correspondence with Dr. Theodore Groom, who, I understand, will shortly publish a paper including a geological study of this part of Gloucestershire, I visited the district last October with a view to collecting such plant remains as could be obtained. I found, as I had anticipated, that there are practically no exposures of the Coal-measures at the present time which offer any opportunity for collecting fossil plants. I had, however, the good fortune to secure the co-operation of Mr. I. Rogers, of Bideford, who very kindly spent some days with me at Newent, and, to his exceptional skill as a collector, such specimens as we were able to obtain are largely due. To him I owe many thanks. I have also to express my indebtedness to a grant from the Government Grant Committee of the Royal Society for defraying the expenses of the field-work.

It fortunately happened that, shortly before my visit, a well had been sunk at Great Boulsden, about 90 feet deep, on the exact site of the old abandoned workings for coal in this locality. The upper 6 feet, I was told, consisted of red rocks, no doubt Trias, and the rest of the section appeared to be Coal-measures. I was also informed that no seam of coal had been passed through, but that it was expected that the coal would be reached at a depth of about 120 feet. At the time when I discovered this sinking, the heap of debris thrown out of the well had unfortunately become badly weathered, partly owing no doubt to the wet nature of last summer. The shales were thus extremely soft and very fragmentary. Collecting was performed by means of the blade of a penknife. However, after several days work, Mr. Rogers and I managed to obtain a few specimens which could be determined specifically, and which will be discussed here.

I may perhaps mention that, through the kindness of Mr. O. T. Price of Boulsden Croft, Newent, I obtained some interesting information as to the year in which the coal was first worked at Boulsden, which does not appear to have been known to those who have written on the geology of this district. Mr. Price showed me a copy of the *Gloucester Journal* for April 26, 1890, in which there was an article recalling the excitement due to the discovery of coal at Boulsden one hundred years previously. Quotations from the *Hereford Journal* of July 7 and 14, 1790, were cited in which it was stated that coal had been raised and burnt in Hereford and Gloucester during the summer of that year. The cost then was 16*s.* a load. Apparently the enterprise did not prove profitable, for the shafts appear to have been abandoned a few years later.

[1] J. Phillips, "The Malvern Hills": Mem. Geol. Surv., 1848, vol. ii, pt. i.

[2] D. G. Lillie, Geol. Mag., 1910, Dec. V, Vol. VII, p. 58.

Some thirty years ago, the Newent Colliery Company sank two shafts on the site of former workings below White House, about three-quarters of a mile due west of Oxenhall Church, to the north-west of Newent. These pits have also been long since abandoned. By digging, however, in the old waste-heaps of this colliery, Mr. Rogers was able to unearth a few fragments of fronds. These were the only other specimens which we could obtain, even after a careful examination of all the outcrops of the Coal-measures in the district.

So far as I am aware no plant remains have ever been previously collected from this coal-field, nor do I know of any reference to such specimens in any book or paper. The fossils discussed here are thus unique as regards locality.

A few fragmentary pith-casts of Calamites occur, one of which is possibly *Calamites Suckowi*, Brongn., but the specimens are too fragmentary to permit of specific determination. Two types of Calamite foliage were found, a single specimen of *Annularia radiata*, Brongn., and several examples of *Calamocladus equisetiformis* (Schloth.), which appears to be common.

Among the Fern-like fronds, those of *Pecopteris* are particularly abundant, and probably more so than any other plant. There appear to be at least three species. Unfortunately, not only does the fragmentary nature of the specimens render them unfavourable for specific determination, but the nervation is as a rule very indistinct. *Pecopteris oreopteridia* (Schloth.), the characteristic nervation of which is seen in several examples, almost certainly occurs and is particularly abundant. *Pecopteris Miltoni* (Artis) appears to be also common. Other fronds apparently belong to *Pecopteris arborescens* (Schloth.), but their attribution is more doubtful, for the nervation cannot be clearly seen in any example, though specimens do occur in which the veins are apparently simple.

Two small specimens, each showing a few pinnules of *Neuropteris rarinervis*, Bunb., were collected, in which the nerves are very clear and characteristic. Fragments of Sphenopterid fronds, recalling *Sphenopteris obtusiloba*, Brongn., were found, but are too small to be determined with certainty.

Small leafy branches of a *Lepidodendron* are frequent, and the characteristic striated bark [1] of an unknown genus, which has been found in several other coal-fields, is also represented. A single, poorly preserved leaf of *Cordaites* completes the list.

The above specimens were all collected from the well-sinking at Great Boulsden. From the disused Newent Colliery heaps, one or two specimens of *Neuropteris Scheuchzeri*, Hoffm., and a fragment of a pinnule with a net nervation, belonging either to *Lonchopteris* or *Dictyopteris*, perhaps the former rather than the latter, were the only plants obtained, with the exception of some Lycopod macrospores.

The collection from the Newent Coal-field is too small to determine the horizon of the beds with certainty. So far as it goes it indicates that the zone is higher than the Middle Coal-measures, but whether Upper Transition Series or Upper Coal-measures cannot be definitely

[1] See Arber, Phil. Trans. Roy. Soc., ser. B, vol. cxcvii, p. 310, pl. xx, fig. 12.

decided at present. The presence of *Annularia radiata*, Brongn., and to a less extent that of *Neuropteris rarinervis*, Bunb., would seem to turn the balance in favour of the Upper Transition Series were it not for the abundance of Pecopterids and the possible occurrence of *Pecopteris arborescens* (Schloth.). Perhaps we may provisionally conclude that these beds belong, either to the highest portion of the Upper Transition Series, or the lower portion of the Upper Coal-measures.

II.—On the Glaciation of the Navis Valley in North Tirol.

By Alfred P. Young, Ph.D., F.G.S., F.L.S., etc.

(PLATES XIX AND XX.)

In a previous paper[1] it was shown that one prominent topographical feature of the Tarntal district, the great cirque called the 'Grübl', could be explained as the effect of erosion by a short ice-tongue which formed when the snow-line persisted for a time at about 2400 metres above sea-level. The basin-shaped hollow of the Upper Tarntal was held to be due to another stand of the snow-limit at 2650 metres. It remains to be seen whether these conclusions are supported by evidence of a similar nature collected over a wider area.

Evidence for Snow-lines in other parts.

The drainage basin of the Navis Valley is bounded on the south by a well-marked ridge in no part lower than 2250 metres, with several summits over 2400 metres; the highest, the Schafseiten Spitze, reaches 2604 metres. On the north slope of this ridge is a row of corries sufficiently conspicuous to be visible from the north slopes of the valley as shown in the photograph, Fig. 1, Pl. XIX. Two of these corries under the ridge between Bendelstein and Schafseiten Spitze certainly held at one time small lakes; the moraine dams at the outer lips are still well preserved at a level of about 2150 metres. The corries are evidently the beds of short ice-tongues which formed when the snow-line stood for a time at about 2250 or 2300 metres.

On the northern slopes of the Navis Valley the corries are not so well developed. On the east slope of the Mieselkopf[2] is a well-marked amphitheatre, the floor of which is somewhat ill-defined. Important accumulations of moraine material are found on these slopes mostly at levels below 2300 and above 2150 metres; these evidently belong to a high snow-line, the level of which was between 2350 and 2400 metres.

Under the ridge which bears the Schober Spitz, 2450 metres, is a small but pronounced lake-basin at a level of 2300 metres, indicating a snow-line at 2350 metres nearly.

Summing up the evidence from different parts of the drainage

[1] Geol. Mag., Dec. V, Vol. VI, No. VIII (August, 1909), p. 339.
[2] See accompanying map reproduced from the Geol. Mag., August, 1909, p. 341.

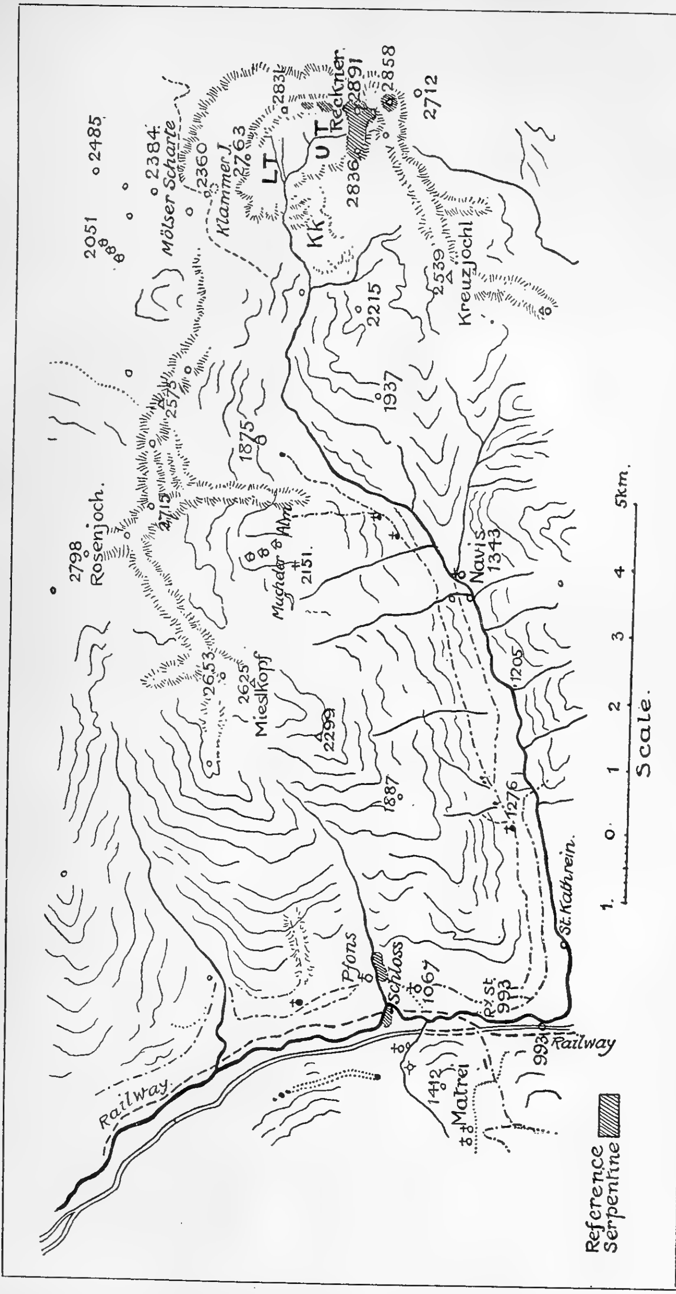


FIG. 1. Sketch-map of the district between Tarntaler Köpfe and Matrei, showing occurrences of serpentine. Height above sea-level in metres from the Generalstabskarte. U.T. Upper Tarntal; L.T. Lower Tarntal; Kk. Knappenkuchel.

area of the Navis Valley, we have for the probable height of the snow-line—

	Metres.
On slopes with north aspect under the Schafseiten ridge	2250 or 2300
At the Grübl with west aspect	2400
Slope with south aspect under Schober Spitz . .	2350
Slopes with east and south-east aspect under Mieselkopf	about 2350

Simple and Compound Corries.

The corries under the Schafseiten Spitze are so simple in form that they may have been excavated during a single stage of glaciation. The dams being still intact, it is clear that the stand in question was made in the course of the last retreat of the ice, marking a late phase in the Würm period of Penck. An earlier period is out of the question; the dams formed would have been swept away by the ice in the following advance.

At the Grübl, the great cirque under the Tarntal, the conditions are more complicated, and only to be explained on the assumption that the work of excavation commenced during one of the earlier glaciations. The rear wall of this cirque is over 300 metres in height. The whole of the water draining from the Upper and Lower Tarntal collects under the screes and reaches the Grübl in the form of big springs which come to the surface little above the floor of the cirque.

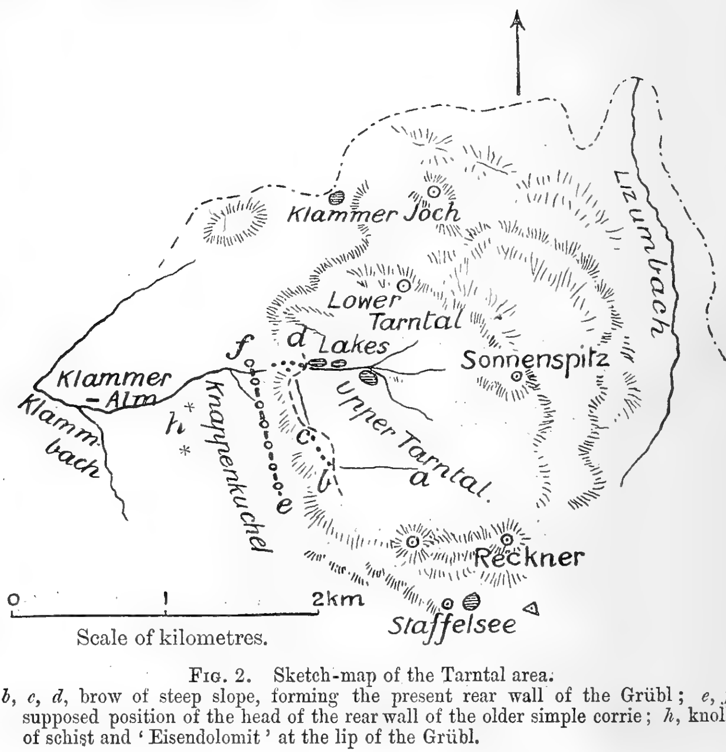


Fig. 2. Sketch-map of the Tarntal area.
b, c, d, brow of steep slope, forming the present rear wall of the Grübl; *e, f*, supposed position of the head of the rear wall of the older simple corrie; *h*, knolls of schist and 'Eisendolomit' at the lip of the Grübl.

Fig. 1.—Corries under Schafseiten ridge.

Bemrose, Collo.

Fig. 2.—Old Floor of the Grübl; the Cirque under the Tarntal.

The annexed diagram (Fig. 2) shows in plan the main hydrographical features. A pronounced north and south groove *c*, *d*, is seen to end at *d* at a level of about 2500 metres, just in front of the lower end of the Lower Tarntal. This groove was at one time the bed of the brook from Upper Tarntal, which was then tributary to the Lower Tarntal. By the retreat of the wall the connexion has been broken in two places, namely, along the dotted line *bc* and near the junction at *d*.

At this earlier stage the wall at the back of the Grübl stood further to the westward as shown by the broken line *e*, *f*. The Grübl was then a simple corrie and received the drainage of both the higher valleys below the junction at *d*. Two other important changes have since been brought about. The floor of the Upper Tarntal has been further excavated so that the level of the latest outlet is lower by some 20 metres than the old watercourse at *b*. The floor of the Grübl has also been further eroded. A former level of this floor is no doubt indicated by the small plain which now makes a conspicuous feature in the landscape as seen in Pl. XIX, Fig. 2. This plain is now some 20 or 30 metres above the corrie floor.

In the case of the Grübl the process of 'gnawing back' must have gone on at an unusually rapid pace, the vertical joints in the dolomitic rocks facilitating the work of demolition, most of which was effected when the snow-line stood at levels between 2200 and 2500.

As long as the floor of the corrie was above the snow-line the blocks may have been detached in great numbers, but being under firn could not have travelled very far. When the snow-line was above 2500 the ice-tongues were much reduced in mass and length and could contribute little to the transport of the boulders. We come back later to the detailed history of the erosion of the Grübl.

Block-wall and Block-waste.

The east and west ridge carrying the Reckner and Little Reckner summits is almost girdled by a great wall of serpentine blocks. The Staffelsee on the south side is somewhat below the foot of the wall. The ridge-line of the wall is at 2600 metres, in parts higher. Fig. 3 of Plate XX is a photograph taken from a knoll about 2600 metres high in the Upper Tarntal to the north-west of Reckner. The crest of the block-wall is seen projected against the snow-field in the middle of the picture and can be traced eastward as far as the contour can be followed to the left.

At first sight the wall might be taken for a moraine, from which, however, it differs in the absence of any binding material. Most probably it is the result of the demolition which went on when the snow-line stood for a time at 2550 metres; the building of the wall was thus contemporaneous with the work of the glacier-tongue which filled the Upper Tarntal during or since the last retreat. The blocks were loosened by alternate frost and thaw, and remained near their original site or rolled down the slope by their own weight till checked. The pile has no doubt received later accessions and is probably increasing still; but its growth was far more rapid when the snow-line was lower.

This form of disruption without transportation finds a striking illustration in the Gross Kaserer, 3270 metres, a subordinate summit of the Olperer group. This peak is now and probably has during Interglacial periods always been above the snow-line. The great crevasses which form between firn and glacier-ice are well developed some way below the summit. The appearance presented is that of a pile of big boulders; the standing rock is not seen. The massive rocks of the Olperer gneissic series break up into blocks too large to be disturbed by the movement of the firn. The mound, moreover, stands out above the firn and has no permanent covering of snow.

This mode of disintegration is not confined to glaciated tracts, and good examples of disruption with little movement are to be found on ancient land surfaces, such as the Indian Peninsula and parts of South Africa. In the Alps the 'Block-meere' or block-wastes are frequent in high ground; most of them were no doubt accumulated when the snow-line stood for a time at a corresponding level.

Erosion To-day in High Ground.

The effects of erosion hitherto treated belong as regards the Tarntal mass to past history, and are referred to conditions of climate other than those at present here prevailing. As already shown,[1] the climatic snow-line is still, in all probability, below the highest summits, and it is instructive to watch the forms of atmospheric activity of to-day.

The serpentine blocks above 2600 metres are covered with wart-like prominences a centimetre or so in diameter; these warts are found occasionally on standing rock nearly up to the summits. They are due to the rapid weathering of the serpentine round the more resistant bastites which form the projecting parts. The prominences are seen on blocks below 2600 metres; at the lower levels, however, they are much worn down and do not seem to be forming afresh. The chief agent in this form of weathering is the nearly pure water trickling from the melting snow which covers the ground for a considerable part of the year.

An instance of the same kind of work is furnished by the well-known 'Karren'. This form of sculpture is peculiar to calcareous rocks; straight grooves resembling the ruts of cart-wheels are crowded together in parallel series and often cover wide areas, the 'Karrenfelder'.[2] The ruts are determined by structures in the limestone, thin bands, bedding-planes, joints; they were no doubt formed under snow, when the snow-line stood at a corresponding level, and are due to the solvent action of nearly pure water. The 'Karren' are only found at high levels; they may be expected to furnish useful information concerning former stands of the snow-line.

A steep slope on the south side of the saddle between Reckner and Little Reckner is covered to a depth of several feet with an incoherent deposit of more or less finely divided serpentine almost free from

[1] See Geological Magazine, August, 1909, p. 346.

[2] Only the simplest form is here described. For details and figures see Max Eckert, "Das Gottesacker, ein Karrenfeld im Allgäu": Wiss. Ergänzungsheft zur Zeitschrift der D. und Ö. Alpenverein.

vegetation. Except for the presence of some larger rock-fragments, the material may be compared with the loose ash which collects round the crater of Vesuvius, with which, however, as regards origin, it has nothing in common.

The loose powder on the Reckner slope must be constantly carried downward by the melting and falling snows, and to the same extent renewed. We have here a hint of the way in which a rock may disintegrate at the level of the snow-limit, and perhaps under the action of firn, where alternations of frost and thaw play an important rôle.

Older Channels of Upper Tarntal.

The higher and older outlet channels on the west side, by which the Upper Tarntal once drained into the north and south channel (*c*, *d*,[1] Fig. 2), are thickly strewed with erratic blocks of Reckner serpentine. Judging from the amount of demolition and erosion which has been effected since these channels were used, they must have been first formed during one of the older glaciations, or at any rate before the last general advance. But the presence of erratics in these old watercourses implies a movement of ice at a level of 2550 metres, and a corresponding snow-limit above the ice and below the summit ridge; in other words, the snow-line must have made an early stand at 2650 metres nearly. The date of this resting stage could hardly have been later than the close of the Riss period or the first advance of the Würm glaciers. Since the serpentine blocks were left in these high channels the rear wall of the Grübl has been cut back by ice, which could only work efficiently as long as the snow-line remained near the level of 2400 metres.

Glacial History.

The history of the Grübl can only be written on the assumption that the snow-line stood on two different occasions at or near 2400 metres, and, again, twice at about 2650 metres. The sequence of events was somewhat as follows:—(1) The older corrie of the Grübl, with the higher floor and the rear wall to west of the present one, was formed during a sojourn of the snow-line at 2400 metres, when the Riss glacier was in retreat. (2) At a later stage of the same glaciation, or in the first forward movement of the Würm, the basin of the Upper Tarntal was excavated down to the level of the higher outlets (*b*), while the snow-line persisted at 2650 metres. (3) During the final retreat, that of the Würm glacier, the snow-line again stood at 2400. On this occasion the floor of the Grübl was lowered and the demolition of the rear wall broke down the connexions at *b* and *d*, as related above. (4) Lastly, a second stand above 2600 metres reduced by 30 metres the floor-level of the Upper Tarntal, the north-west outlet was pierced and subsequently dammed, since which no advance of the ice has taken place.

Incidentally it may be observed that as far as this evidence goes there is no necessity to suppose that the snow-line ever rose above 2650 metres during the interval between the Riss and the Würm period. The climatic snow-line to-day is here at least as high as 2750 metres.

[1] See Map, Fig. 1, p. 245.

The question whether the last stand at 2650 metres was an event in the closing history of the Ice Age as the Daun advance, or merely a recent incident of climatic oscillation, is left undecided.

The level of the snow-line when it stood for a second time over the Grübl may have been somewhat lower than the first stand near 2400 metres; so also the second stand in the Upper Tarntal may have been somewhat under 2650 metres, the new floor in both cases being lower than the old.

The Navis Valley Drift.

The assumption underlying all the above conclusions, namely that snow-line and firn-line coincide, is safe enough as regards the small glaciers of the corries, and is probably not far from the truth in the case of the glaciers taking their rise in the Tarntal Mountain, especially during the retreating stages, when the area covered by firn and snow was never very large. It may, indeed, be doubted whether at so high a level as that of Navis (1343 metres) any glacier-ice was contributed by the firn from the Tarntal during the extreme of the Würm period, when the snow-line was below 1200 metres at the northern border of the Alps.

On the evidence of erratics from the Central Alps, it has been inferred that the ice-surface in the Inn Valley during the last maximum of cold must have reached a height of 1800 metres or more.[1] The snow-line in these parts could not at the time have been higher than 1200 metres. The significance of the evidence will be considered later. It seems that under circumstances massive ice may accumulate much above the level of the snow-line at the place.

The Inn Valley glacier in this case must have formed a high dam in front of its tributary the Sill.[2] It does not follow from this that the ice in the Sill Valley rose to the same high level. The ice flowing from the Inn up the Sill Valley was retarded by friction and wasted by ablation. It met the Sill glacier at the point at which the two tongues had equal amounts of moving energy. The Navis Valley in turn was dammed by the ice of the Sill, and it is important to determine the height of the ice-surface in this valley during the Würm period.

At a level of 1300 metres, close to the settlement of Navis, are found some blocks of gneiss which could only have been brought by the ice of the Sill Valley (or Wipptal) to which the Navis is tributary. The blocks probably came from the Olperer Alps. They were borne down the Sill tributary in the Valsertal, and were carried by the back flow of the Sill ice into their present position.

I learn from the Pfarrer of Navis, who first called my attention to these blocks, that the stone is in good demand for building purposes, and that one big boulder of gneiss has been quarried completely away. I take this opportunity of expressing my thanks to the Pfarrer, the Rev. Johann Schileo, for this and for much welcome information concerning the topography, many useful names being incorrectly given or omitted altogether on the maps.

[1] A. Penck & E. Brückner, *Die Alpen im Eiszeitalter*, 1907–9, pp. 268, 1143.

[2] See Map, p. 341 of this Magazine for August, 1909. The Sill is the stream shown on the western border of the map, reproduced here on p. 245.

The highest level reached by these gneiss blocks cannot therefore be precisely known. But the valleys of the Klamm and Weidereich brooks which join to form the Navis are hardly accessible enough from the inhabited parts to have been exploited by cottagers in search of stone, and it is unlikely that the Sill erratics were carried much above the level of Navis even during the period of extreme glaciation to which their transport is to be referred.

In the Klamm Valley, just above Navis at about 1400 metres, is a conspicuous bar of moraine material, so little above the point reached by the crystalline erratics that it may well mark the site at which the Klamm Valley glacier was met by the back-flow of the Sill ice. It is, however, more likely that this is the end moraine which was formed by the Tarntal ice-tongue during a retreating stage of the Würm, at which time it may be supposed that the Sill ice was also in retreat. In either case the ice-surface could not have stood much higher than 1500 metres. The valley drift which in a measure determines cereal cultivation does not reach above 1600 metres, and may belong in part to an older glaciation.

In one part of the Navis Valley, on the north side near the Wetterkreuz at 2151 metres, there is a marked change in the surface gradient, the slope being much steeper below the Wetterkreuz than above it. If this ledge is the rim of an ice-trough it most likely belongs to one of the earlier glaciations, when the floor of the valley and the snow-line were both higher than they were during the latest, the Würm glaciation. But the gently sloping floor above the Wetterkreuz may be accounted for as a plain of nival denudation, the 'Abtragungsebene der Schneegrenze' of Richter.[1] The masses of moraine material above 2200 metres which accumulated during the persistence of the 2400 metre snow-line make this explanation the more acceptable. Taking all the evidence together, it appears most improbable that the ice-surface was at 2100 metres when the Schafseiten corries were last occupied by ice, or even when they were first formed, supposing them to have been more than once filled with ice.

Of the four resting-stages which have left their traces in the Tarntal district two may be doubtfully correlated with Glacial periods recognized elsewhere.

The bar or 'Riegel' at 1400 metres in the Klammbach may be the equivalent of the moraine deposits above Trins in the Gschnitztal, the 'Gschnitzstadium' or γ stage of Penck. The Trins glacier rising in the high ground of the Stubaital Alps would naturally end at a lower level than the glacier of the same date in the Navis Valley with a much smaller feeding-ground. It should, however, be noted that the terminal moraine of the γ stage is placed by Penck at the mouth of the Navis Valley.[2] The post-Würm snow-line of the Grübl at 2400 metres would appear to be somewhat higher than that of the γ stage of this valley, to which Penck assigns a level of 2100 metres. For the Gschnitztal the snow-line of the γ stage is fixed at 2300.

[1] E. Richter, "Geomorphologische Studien in den Hoch-Alpen": Petermann's Mittheilungen Ergänzungsheft, 1900, vol. cxxxii, p. 77.

[2] Penck & Brückner, *Die Alpen im Eiszeitalter*, 1907–9, p. 343.

On the analogy of the present nival gradient the ancient snow-limit in the Navistal should have been lower than in the Gschnitztal.

The latest post-Würm stand recognized in the Tarntal at about 2650, certainly not lower than 2600 metres, represents a depression below the present snow-line of about 150 metres. It may turn out to be the equivalent of the Daun stage, when the snow-line is supposed to have been lowered to the extent of 300 metres.[1]

The two pre-Würm stages of the Tarntal with snow-lines at 2400 and 2650 metres respectively cannot be identified with any of the stationary periods hitherto recognized.

Definition: 'Nival Plane' and 'Nival Gradient'.

In the discussion which follows account must be taken of the contemporary variation in the height of the snow-line in different parts of the Alps.

The small map compiled by Hess[2] from a great number of observations shows the present snow-line near the central ridge some 800 metres higher than that on the border of the region now covered by snow.

The imaginary surface containing all the different snow-lines of the same period may be called the 'nival surface', or more simply 'nival plane'. The latter term is sufficiently appropriate to present conditions; the rise of the snow-line over considerable spaces being, as Hess's map shows, nearly proportional to the horizontal distance. The angle made with the horizon by the nival plane is the 'nival gradient'.

Use of Maps in tracing Ancient Snow-lines.

In order with the help of maps to trace over a wider area the extension of the snow-line during any one stationary period, it is necessary to know for each stage the orientation of the nival plane; only in this way will it be possible to sort correctly into their respective groups all the traces of the several nival surfaces.

The snow-line in the Alps of to-day is, as we have seen, found to rise as much as 600 or 800 metres as the axial ridge is approached from the border of the snow-covered district. The change in level is no doubt mainly due to variation in the amount of annual precipitation, the belt of maximum rainfall being in places as low down as 1800 metres,[3] seldom much above 2000 metres.[4]

It cannot on *a priori* grounds be assumed that the zone of maximum precipitation stood at the level at which it is found to-day, or that it varied according to any definite rule with reference to the position of the nival plane. It has, however, been inferred from the heights of corrie-floors and other evidence that the snow-lines of previous cold periods ran on slopes approximately parallel with that of to-day.[5]

[1] Penck & Brückner, *Die Alpen im Eiszeitalter*, pp. 348, 635.
[2] H. Hess, *Die Gletscher*, 1904, p. 74.
[3] Ibid., p. 44.
[4] J. Hann, *Handbuch der Klimatologie*, 1908–10, p. 258.
[5] A. Penck & E. Brückner, loc. cit., p. 1144. E. Richter, *Gletscher der Ostalpen*, p. 277 (quoted by Penck).

Karwendel Gebirge.

Professor Rothpletz has called attention to the corries[1] of the Karwendel Gebirge, and much can be learnt from his work[2] and the large scale-map which accompanies it.

Interpreted according to the method here used, the corries of the outermost chains of the Karwendel give evidence of one or two snow-lines at a lower level than those observed in the Navis district. The Great Soiernkessel on the north side of the ridge is a characteristic corrie. The floor at 1546 metres is marked by a lake with a dam of standing rock.[3] The ridge at the back bears several summits higher than 2000 metres, the highest, the Soiernkarspitz, reaching 2260 metres. This indicates a long stand of the snow-line in the neighbourhood of 1700 metres.

The Krapfenkar and Mondscheinkar, also in the 'Vordere Karwendelkette', have floors at 1700 or 1800 metres, under ridges of 2100 metres, indicating a stand of the snow-line at 1850 metres nearly. The floors appear to be ill-defined, and the stand in question is probably to be referred to one of the older glaciations. The higher lake of the Soiernkar at 1836 metres may belong to this stage.

In the 'Hintere Karwendelkette', south of the last-named ridge, are several corries with floors at 2100 to 2300 metres. The summits on the ridge reach heights of 2550 to 2750 metres. This requires a snow-line at 2350 metres or higher. These corries may be companions of the Grübl and Schafseiten group of the Navistal.

Traces in other parts of the Alps of the 2650 metre snow-line should be sought in the first instance on ridges of the same height as the Tarntaler Köpfe (Reckner, 2891 metres) and at the same distance from a high snowy range as Tarntal is from the Olperer.

About 3 kilometres south of the Sonklarspitze in the Stubaital Alps is a ridge of the required height. Several summits reach 2880 metres, and one, the Scheiblehner, rises to 2991 metres. Just below is a large lake, the Schwarzsee, 2548 metres above sea. This lake-basin may well be a contemporary of the corrie of the Upper Tarntal. The above details are taken from the Austrian Generalstabskarte, Sheet Sölden.

The Scheiblehner is nearer to the Central Alps than the Tarntal, and according to analogy the corresponding snow-line should be somewhat higher. More precise determinations of levels may show this to have been the case.

Denudation under Firn and Snow.

On the slopes of snow-covered mountains there must be a belt of the land surface at which the frequency of the oscillations of temperature about the freezing-point of water is a maximum. (Here

[1] The corrie is a feature which gives the motive for topographical names. The equivalents for 'corrie' in other languages will be useful. They are: Welsh *cwm*, Norwegian or Danish *Bodt*, pl. *Bodter*, German *Kar*, pl. *Kare*, also *circus*, French *cirque*, Spanish *hondon*, Indian (Quecha) *cuchu*; the last two names are used in the Equatorial Andes (W. Reiss). W. Reiss & A. Stübel, *Das Hochgebirge der Republik Ecuador*, 1902, ii, p. 164.

[2] A. Rothpletz, *Das Karwendelgebirge*.

[3] Ibid., p. 71.

the surface under the ice-tongue is not considered.) This zone does not necessarily coincide with the snow-line; it is to be sought near the isotherm of 0° C. of mean annual temperature, which in the Alps is probably above the snow-line.[1] It may be that the standing rock under the firn is subject to frequent alternations of the kind in question; the changes may then be determined by variations of pressure and other causes only indirectly dependent on the temperature of the air; the freezing-point under a heavy cover of firn may be other than zero Centigrade.

Above the zone indicated the oscillations of temperature about freezing-point diminish in frequency with the height, for not only is the mean annual temperature reduced, but the range of temperature-variation is narrowed in ascending,[2] and if denudation still goes on it must be due to other causes.

It might be expected that a study of the volcanic cones which project above the snow-line would throw light on the question whether a cover of firn serves to protect the land surface. From the observations of E. Richter[3] in the Alps, I. Russell[4] on Mount Rainier, W. Reiss[5] in Ecuador and Colombia, it seems clear that the glaciers at the snow-line are the most active agents of destruction. According to Russell the work of demolition goes on with the greatest activity along the crevasses which form at the firn-line. The beds of the glaciers are continually receding, with the result that, to use Richter's phrase, the mountain is ultimately beheaded at the snow-limit.

The outlines of extinct volcanoes which have been long subject to this levelling action are well shown in Hans Meyer's photographs of Sincholagua and Quilindaña.[6] In the latter figure the plain of nival denudation is especially conspicuous. The sketches given by A. Stübel,[7] preserving, as they do, the correct relation between vertical and horizontal dimensions, are also instructive.

Russell[8] maintains that above this zone of rapid disintegration the ground is protected by the snow and firn, especially at higher levels, where the snow retains the powdery form until it is removed by the wind or falls to lower levels.

Admitting the facts, the proof that a cover of firn or snow retards erosion is still incomplete. In estimating the comparative rates of erosion all the variables must be taken into account, for example—

(1) The amount of precipitation varies with the height above sea. It reaches a maximum in the Alps at 1800 to 2400 metres, and above this level diminishes with the height. In other regions, with average rainfall, this maximum is accordingly to be looked for at levels below the snow-line.

[1] See J. Hann, *Handbuch der Klimatologie*, p. 268. In the Eastern Alps near Innsbruck the temporary isotherm 0° C. is below the snow-line only during the winter months.

[2] H. Hess, loc. cit., p. 41.

[3] E. Richter, *Geomorphologische Studien in den Hoch Alpen*.

[4] I. C. Russell, "The Glaciers of Mount Rainier": U.S. Geol. Surv. Reports for 1896–7 (1898), vol. xviii, p. 382.

[5] W. Reiss & A. Stübel, *Das Hochgebirge der Republik Ecuador*, 1902, ii, pp. 165, 173.

[6] Hans Meyer, *In den Hoch-Anden von Ecuador*, Berlin, 1907.

[7] *Die Vulcanberge von Ecuador*, p. 407.

[8] I. Russell, loc. cit., p. 382.

(2) On slopes at lower levels, where local precipitation is reinforced by the flow from above, the activity of water must be greater than on the high ridges which receive only the snow or rain falling directly on them.

Relation of the Corrie-floor to the Snow-limit.

In general, reliable evidence for any one stand of the snow-line will be found on suitable slopes under ridges which rise only a few hundred metres above the snow-limit. This is the condition for the formation of corries. In such cases the ice-tongues will be short, the firn-line will coincide with the snow-line.

Under higher ridges the ice-tongues of the same period will be longer, the beds will be in the form of troughs rather than basins. In still higher ground the beds of glaciers belonging to successively higher snow-lines will join to form a continuous groove, which gives no indication of a stationary period.

Further, low ridges too near the centres of glaciation will be whelmed in ice from the high ground. Corries will thus be formed only near the border of the tract for the time being under glacial conditions, the different stands of the snow-line will leave their traces on successively higher ridges nearer the centre, the lowest corries corresponding to maxima of cold being on the extreme border of the area occupied by ice. Such is, in fact, the distribution of corries actually observed.

All pronounced corries are held to bear precise and unequivocal testimony to some one stand of the snow-line, during which the ice just filled the hollow. None of this evidence can be neglected. Corries with moraine dams must have been filled with ice during the latest retreat, the loose material being unfitted to withstand the thrust of moving ice of any later advance.

The basin-like hollow of the corrie is the counterpart of the trough occupied by the long glacier tongue. Amphitheatres with ill-defined floors are either the sources of longer ice-streams or are the walls of ancient corries, the floors of which have been broken down by a subsequent advance of the ice.

This explanation of the origin of corries differs somewhat from those hitherto in use. The site of the corrie was determined by the height of the snow-line, the height of the ridge, the catchment area, the conditions of precipitation and insolation on which depended the length of the ice-tongue. A watercourse or groove led the firn in the required direction. There was no other marked hollow. Where several corries are found at nearly the same level it cannot be supposed that each was determined by a pre-existing pit or funnel.[1] The formation of corries is not limited to extremes of glaciation. At the time the corrie was formed the snow-line was not on the level of the floor,[2] but considerably higher. The level of the corrie-floor is in no way related to the level of the ice-surface in the main valley to which the corrie-watercourses were tributary.[3]

[1] See James Geikie, *The Great Ice Age*, 1894, p. 237.

[2] See Böhm, *Die alten Gletscher der Mur und Münz*, 1900, p. 19; also Richter, *Geomorphologie*, pp. 15, 75.

[3] See Penck, *Die Alpen im Eiszeitalter*, p. 285.

If the views here set forth be correct, the lip of the corrie marks the lower end of the ice-tongue under which the basin was excavated; the boundary of the glacier is defined by the lip and the watershed of the catchment area above it. By means of these data some precision could be introduced into the computation of the corresponding snow-line. Brückner[1] has found that about one-third of the whole surface covered by a glacier belongs to the tongue; thus the contour-line which marks off the lower one-third portion from the upper two-thirds of the glaciated area is the snow-line. Where contoured maps on a large scale are available, a rule such as this, though empirical, should give good results in the case of corries, the areas dealt with being small.

Erosion under the Ice-tongue.

The direct action of glacier-ice in wearing and scouring the standing rock is here accepted as an established fact. It has not been thought worth while to qualify the terms in which this postulate is implied. For the purpose of this paper, however, it would suffice to assume merely that the bed of a glacier tongue differs distinctly in form or dimensions[2] from that of a channel eroded by running water alone. The truth is that all conclusions hitherto drawn regarding the relative rates of erosion by ice and by water are of doubtful validity. The two processes cannot be observed apart.

The facts to be taken into account are—

The glacier tongue being below the snow-line, where all the snow that falls within the year melts within the year, the whole of the local precipitation must reach the land surface under the ice as running water by the numerous clefts which form at the firn-line and below it. Generally, however, the channels in the ice deflect the water, which thus reaches the bed not at the point directly under the spot at which it falls, but lower down the valley.

Some snow above the firn-line melts and reaches the bed to form part of the stream. The snow-line is only the limit at which the falling snow just balances the melting snow.

The whole of the glacier-ice is contributed by the firn, that is, by a part of the precipitation above the snow-line. By ablation this all joins the stream at various points above the lower end of the ice-tongue, so that the water running out at the ice-portal during the year is exactly what with the same amount of precipitation would flow over the bed at this place if no glacier existed.

The glacier-bed is a water-channel as well as an ice-channel; the form taken by the bed is due to the combined action of water and ice.

Gradient of Glacier-ice.

The gradient of the ice surface during the last maximum of cold has been inferred from a great number of records by various observers

[1] Brückner, *Meteorologische Zeitschrift*, 1887, p. 31. Hess, *Die Gletscher*, p. 74. The ratio actually observed diverges widely in extreme cases from Brückner's mean. Richter holds that the proportion of glacier-ice to firn is, as Brückner himself hints, more nearly 1 : 4 than 1 : 3 (E. Richter, *Gletscher der Ost Alpen*, 1888, p. 41). Hess adopts the ratio 1 : 3·1 (loc. cit., p. 83).

[2] See A. Penck, "Uebertiefung der Alpentäler": Internat. geogr. Congress, 1899, p. 239.

who have noted the highest occurrences of ice scratches and erratics in different parts of a valley.[1] In the application of this method some caution seems to be necessary. On the analogy of present conditions and on the ground of direct observations, it may be admitted that the nival gradient was, at least in the higher ground, always as steep as it is to-day. It is perhaps not out of the question that massive ice formed above the snow-line even in the high ground. But if the rise in the snow-line was due to diminished precipitation it is difficult to suppose that the firn-line stood very much higher than the snow-limit. Even assuming for the maximum of cold a somewhat steep nival gradient and a firn-line high above the snow-line, it can hardly be doubted that ice would form at successively higher levels during the retreat. The highest scratches may thus belong to milder periods; so too the highest boulders in ground near the centre of glaciation.

The highest crystalline erratics in the neighbourhood of the Alpine foot-hills no doubt belong to a period of extreme cold, but not necessarily to the last maximum; boulders of earlier glaciations might persist for an indefinite time if landed between the tributary water-courses on shoulders and spurs where they would not be disturbed by the ice of a subsequent advance.

The inclusion in the estimate of boulders and scratches belonging to retreating stages would give for the maximum an ice-gradient steeper than was actually attained in the higher parts of the valleys. To include in the estimate boulders which were landed during some older glaciation when the valley-floor was higher would lead to false conclusions as to the thickness of the ice in the lower reaches of the valleys.

Relation between Nival Plane and Zone of Maximum Precipitation.

The hypothesis that the rise in the snow-limit is mainly the result of diminished precipitation in the high ground leads to some interesting deductions concerning the relation between nival surface (N.S.) and belt of maximum rainfall (M.P.). At the present time the nival

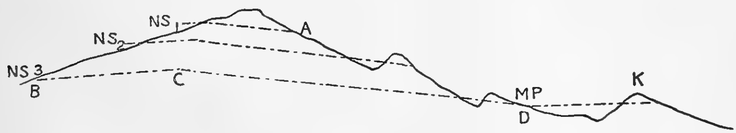


Fig. 3. Diagram showing break in the nival gradient when the nival surface passes through the zone of maximum precipitation.

surface (N.S. 1, Fig. 3) on the northern slopes of the Alps is nearly a plane,[2] all parts of which are above the zone of maximum rainfall.[3] With these conditions as a starting-point we may consider the following hypothetical cases:—

Case 1. If while M.P. remains stationary N.S. is depressed continuously, it takes up successive positions as N.S. 2, nearly

[1] Penck & Brückner, *Die Alpen im Eiszeitalter*, p. 604.
[2] See Hess's map, loc. cit., p. 74.
[3] Hess, loc. cit., p. 44; J. Hann, *Klimatologie*, 1905, p. 262.

parallel to N.S. 1, until it falls so low as to pass through M.P., as at C.D. Then that part of the nival surface beyond M.P. will not be in the same plane with C.D., but will be horizontal nearly, or may even rise in the contrary direction if the outer ridges like K. are too small to cause by their own mass a marked increase in the precipitation (Fig. 3). This break will be maintained as the nival surface continues to fall.

Case 2. As N.S. falls M.P. is depressed to the same extent, but the amount of precipitation remains constant. In all the new positions N.S. remains parallel to N.S. 1. The supply of firn in the high ground is much reduced.

Case 3. As in the last case M.P. falls at the same rate as N.S., but the amount of annual precipitation is much increased.

Case 1 seems to be inconsistent with parallelism of the nival planes through all stages of glaciation. Seeing, however, that the zone of maximum precipitation stands in winter at the level of 1000 metres or lower,[1] this difficulty would vanish if it could be shown, as Penck suggests,[2] that during the ice period the precipitation took place mostly in the coldest part of the year. But with this modification case 1 is open to the same objection as the following one.

The hypothesis that N.S. and M.P. rise and fall in company is the most probable one. Case 2 does not, however, provide for a supply of ice sufficiently copious to fill the lower reaches of the valley up to or even above the level of the local snow-line, as seems to have happened in the Inn Valley during extremes of cold.[3]

It remains to consider whether case 3, which would account for some of the most salient facts of Alpine glaciation, is admissible.

EXPLANATION OF PLATES.

Plate XIX.

Fig. 1. Corries on the north slope of the ridge between Schafseiten Spitz (2604 metres) and Bendelstein (2422 metres). From a point on the slope of the ridge east of Mieselkopf, distant about 6 km. Looking south.

Fig. 2. The horizontal surface a little above the middle line of the picture, probably a plain of nival denudation, is held to indicate a former level of the floor of the Grübl. View taken from a point about 2100 metres above sea on the slope under the Schoberspitz, distant about 1 km. Looking south-east.

Plate XX.

Fig. 3. Wall of serpentine blocks forming an almost complete girdle round the Reckner ridge at a level of 2600 metres and upwards. From a knoll in the Upper Tarntal 2600 metres above sea, distant about 0·75 km. Looking south-east.

III.—Notes on new or imperfectly known Chalk Polyzoa.

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

(PLATE XXI.)

(*Continued from the April Number*, p. 147.)

Membranipora Woodwardi,[4] nov. Pl. XXI, Figs. 1–3.

Zoarium free or adherent, always unilaminate.

Zoœcia large, subpyriform, with broad margins sloping slightly inwards and expanding at the foot into a short front wall; areas

[1] J. Hann, *Handbuch der Klimatologie*, 1905, p. 262.
[2] Penck & Brückner, loc. cit., p. 1145.
[3] Loc. cit., p. 268.
[4] Dedicated to the Editor.

Bemrose, Collo.

FIG. 3.—Block-wall under Reckner-ridge.

elliptical, length ·5 to ·75 mm., breadth ·31 to ·45 mm., tapering towards the head, across which stretches a slight internal shelf, which straightens the apparent outline; from the edge of this shelf hangs a stout oval ring, which connects it with the floor of the zoœcium; zoœcial boundaries distinct.

Oœcia very large, almost square; the free edge runs out over the area for a short distance and is then cut back in a curve parallel to the edge of the area beneath.

Avicularia subvicarious, forming the initial zoœcia of new rows; they are practically small and narrow zoœcia pinched together at the top into a beak and spanned slightly below the middle of the area by a very slender bar, of which only the broken ends are usually preserved; in the immature stage found in the *M. cor-anguinum* zone this beak is very short and markedly unsymmetrical, in the higher zones it is greatly produced and nearly or quite symmetrical.

Found occasionally in the zones of *M. cor-anguinum* and *Marsupites*, and freely in the zone of *Act. quadratus* in Hants and in the zone of *M. cor-anguinum* at Gravesend.

Membranipora coralliformis, nov. Pl. XXI, Figs. 4 and 5.

Zoarium adherent, sometimes tuft-shaped, but very generally forming long narrow bands.

Zoœcia elliptical, very small; length of area ·24 to ·3 mm., breadth ·15 to ·2 mm.; primarily they are quite simple, but along the walls of mature zoœcia there forms a thick, continuous, smooth incrustation pierced by numerous short tubes, giving it a madreporiform appearance; the tubes show a weak tendency to regularity of occurrence, there being usually a pair, one on either side of the upper part of the area; this incrustation may overhang the area or recede from its edge, which can then sometimes be seen to be studded with tiny perforate tubercles; the incrustation often envelops the oœcium, leaving only the aperture distinguishable. Among the tubes may be sometimes found miniature avicularia.

Oœcia globose, free edge curved inwards.

Avicularia vicarious, rare except along the edge of zoaria, wide at the head, and tapering towards the foot, close to which they are spanned by a slender bar, of which, as a rule, the broken ends alone are preserved as a slight constriction of the outline; the broad elliptical aperture is coterminous with the walls in the lower part, but in the upper part is surrounded by an internal shelf.

Found in the zone of *M. cor-anguinum* at Gravesend (abundantly) and in Hants.

Pseudostega, gen. nov.

Diagnosis.—A genus of Membraniporidæ in which a secondary zoœcial layer is formed over and arising out of a layer of ordinary Membraniporidan zoœcia.

This genus seems to be analogous among the Membraniporidæ to *Steginopora* among the Cribrilinidæ. The secondary layer apparently arises from the walls of the primary layer, and if so the essential difference between *Pseudostega* and *Membranipora coralliformis* is little more than one of degree.

PSEUDOSTEGA CANTIANA, nov. Pl. XXI, Figs. 6 and 7.

Zoarium adherent.

Zoœcia in the lower layer fairly large; length of area ·3 mm., breadth ·2 to ·22 mm.; in the upper layer they have only vaguely defined outlines and are very variable in minute details, but are very uniform in general structure; they run in very straight and regular alternating rows, in which, after the initial zoœcium, all have a large area, with a stout denticle projecting into it at the foot and directed slightly downwards, and, as a rule, a small curved indentation opposite to it at the head, possibly representing the aperture of an immersed oœcium; across the area stretches a broad bar, shaped like a very shallow V pointing downwards, which divides the area into two compartments, of which the lower is the smaller and is reduced by the point of the V and the marginal denticle to the shape of an eight lying on its side; at the foot the area is overlooked by two tubular prominences on the marginal wall separating it from the area of the preceding zoœcium; these might naturally be taken to represent two avicularia of the preceding zoœcium uniformly present in the lower layer, but I cannot find any traces of paired avicularia being regularly present there, the nearest approach lying in the tiny paired slits which can be seen at the head of some of the zoœcia of the lower layer in Fig. 7, a figure of the only specimen in which the lower layer is exposed except at the very edge of the zoarium. The initial zoœcium of a row has the point of the V directed upwards and a denticle projecting from one side of the upper compartment; the lower compartment is much reduced and irregular in shape, and there is a single tubular prominence at the foot. This general system is much obscured by crowding in the early stages of the zoarium, but is remarkably regular in the later stages.

Rare in the *M. cor-anguinum* zone at Gravesend and Chislehurst. *Reptescharipora rustica*, D'Orbigny, by its general appearance should be closely related to this species, but as Canu [1] makes it a *Steginopora* it must be assumed to have a Cribriline lower layer.

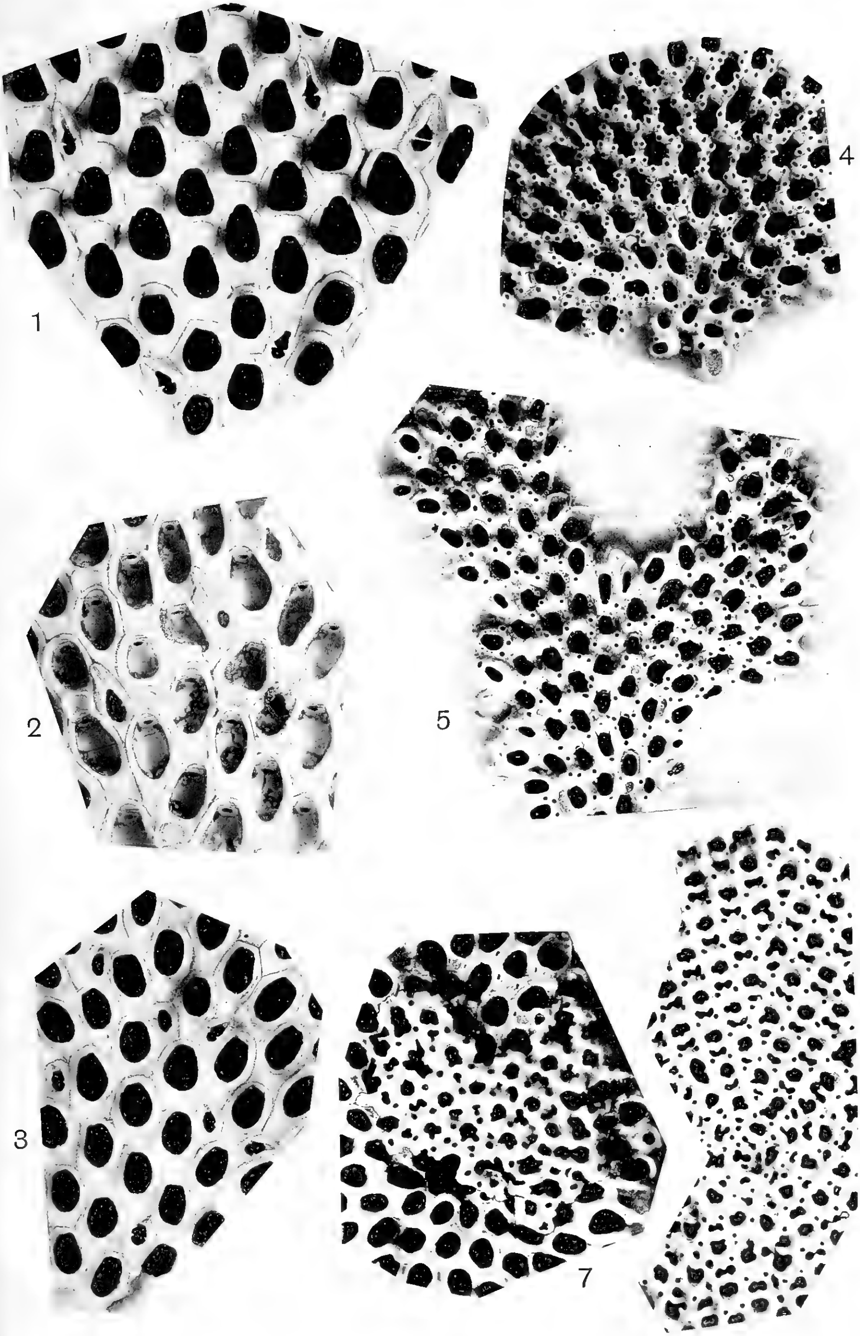
EXPLANATION OF PLATE XXI.

(All figures × 12½ diam.)

FIG. 1. *Membranipora Woodwardi*, zone of *Act. quadratus*, Hants.
,, 2. Ditto, zone of *Act. quadratus*, Hants. Lighted to show up the interior of the zoœcia.
,, 3. Ditto, zone of *M. cor-anguinum*, Gravesend.
,, 4. *M. coralliformis*, zone of *M. cor-anguinum*, Gravesend.
,, 5. Ditto, zone of *M. cor-anguinum*, Gravesend. From the tip of a large branching zoarium.
,, 6. *Pseudostega Cantiana*, zone of *M. cor-anguinum*, Gravesend.
,, 7. Ditto, zone of *M. cor-anguinum*, Gravesend. Lower layer in focus, upper layer rather out of focus.

[1] Bull. Soc. Géol. France, 1900, p. 456.

(*To be continued.*)



R. M. Brydone, Photo. *Bemrose, Collo.*

CHALK POLYZOA.

IV.—On the Systematic Position of the Upper Cretaceous Dinosaur *Titanosaurus*.

By Baron Francis Nopcsa.

Being prevented by other work from continuing at present my work on the Danian (Laramie) Dinosaurs of Transylvania, I wish briefly to draw attention to the fact that the Upper Cretaceous *Titanosaurus*, as known from the Montagne Noire in France and from the Cretaceous formation of Argentina, and perhaps also from East Africa (as already pointed out by Fraas), has nothing to do with the Sauropoda, but belongs to the Trachodontid Orthopods, as proved by the abundant Transylvanian material at my disposal.

Without attempting to enter at present into the question of generic identity of the American, African, and European Upper Cretaceous Titanosaurs, I wish to point out that the Montagne Noire and the Transylvanian Reptiles are generically identical and must be known as *Telmatosaurus*, the name *Titanosaurus* being only applicable to the English Wealden Sauropod described in 1887 in the Quarterly Journal of the Geological Society. The striking survival of a Sauropod so late as the Danian may therefore be questioned, and the time-table in that most interesting recent paper "Distribution and Range of Dinosaurs", by Professor R. S. Lull, must therefore be modified accordingly.

The *Telmatosaurus*, to the tail of which the '*Titanosaurus* vertebræ' belong (as proved by Transylvanian undescribed material), is a heavily built Trachodontid animal, with a straight Stegosaur-like femur (small fourth trochanter), a heavy and relatively strong humerus, nearly solid bones, and probably *quadrupedal* locomotion. Being the only Iguanodontid animal which we can suppose to have secondarily descended on its fore-legs (as *Stegosaurus*, etc., had done after passing a *Scelidosaurus*-like stage of evolution), *Telmatosaurus* deserves special attention. Since *Telmatosaurus* is accompanied in Transylvania by another Dinosaur (*Mochlodon*) which, according to its degree of specialization, would rather correspond with the Lower Cretaceous than with the Danian, and since the same is also true of the *Telmatosaurus* itself (see Sauvage's remarks on *Telmatosaurus* = *Limnosaurus* in *Rev. Crit. de Palæozoologie*), the Dinosaurian fauna of Transylvania bears the same relation to the American Laramic fauna as the recent fauna of Australia to that of the recent fauna of the rest of the world.

V.—The Geology of the Dolgelley Gold-belt, North Wales.

By Arthur R. Andrew, M.Sc., F.G.S.

(*Concluded from the May Number*, p. 211.)

Bryn-y-groes Lode.—About 500 yards east of the Clogau lode, there is a parallel lode which has been worked for copper. Striking 50° east of north, its outcrop may be traced for about 1½ miles; its width is very variable. Chalcopyrite and pyrites and a little gold are present in the quartz. The lode is confined to the Vigra Beds, and running with the beds, it is associated throughout its length with greenstone sills.

Bryntirion Lode.—East of the Bryn-y-groes lode is another parallel lode, with, however, a strong dip to the south-east. Like the Bryn-y-groes lode it is poorly mineralized, and has been worked but little. It is confined throughout its length of three-quarters of a mile to the Vigra Beds, and it is but seldom associated with the intrusive greenstones.

Garth-gell Lode.—At its northern end this lode crosses the junction of the Afon Cwm-Mynach and the Nant-Cesailgwm, and from there it has been traced 200 yards to the south. Its strike is 25° east of north, and its dip vertical. It traverses the Vigra Beds all the way, and is associated with small greenstone sills and dykes. Throughout its length its width is very variable. In many places it has clay selvages along its walls, but these are not constant. The quartz of the vein is hard, white, and often drusy; pyrites and chalcopyrite are the most frequent minerals, and with them also are found blende, some galena, muscovite, and chlorite. In 1900, 26 tons of quartz were milled for 5 ounces of gold.

Maes-tryfer Lode.—This is an unimportant vein which crosses the line of the Garthgell lode close to the junction of the Cwm-Mynach and Cesailgwm streams. Different from all the lodes already described, its strike is no longer north-easterly, but 30° south of east. It courses through the Vigra Beds, and is confined to very near their junction with the Clogau Slates. Little work has been done on the lode, and its characters are not known.

Cambrian Lode.—300 yards above the point where the Afon Cwm-Mynach enters the estuary, the outcrop of a quartz lode is seen in the stream. It courses in a north-east and south-west direction (65° east of north) and can be continuously traced for about half a mile. It is vertical throughout its length; its walls are well defined, and in places have selvages of clay, 2 or 3 inches thick. The vein is poorly mineralized, the chief minerals which do occur being galena, chalcopyrite, and blende, for the first of which the lode was once worked. The lode crosses the Vigra Beds of the Maentwrog Series.

The Voel Group of Lodes.—About the year 1860 there were several companies mining different portions of the lodes of this group, each mine being known by a distinctive name, Princess Alice, Prince of Wales, Glan-y-morfa, and Moel-Ispri. Later (1900–4), these lodes were worked by the Voel Company. There are three separate parallel lodes on the property with numerous small stringers. The strike of the lodes is north-easterly, changing from 70° east of north on top of Foel Ispri, to 50° east of north near the turnpike road. The most southerly of the parallel veins (that nearest to the estuary) has been opened up in several places, and has a shaft extending below sea-level. The lode is from 1 to 3 feet wide, with clearly defined walls. The quartz contains a large amount of blende, along with some chalcopyrite, pyrites, and pyrrhotite.

The intermediate lode of the three cannot be clearly seen; it is opened up by a few cross-cuts into the side of the hill, but these are no longer accessible. The uppermost and most northerly of the Voel lodes dips usually to the south, but in places towards the north the lode is seldom less than 3 feet in width, often much more. Leaders and stringers are frequent, but otherwise the walls are well defined. The blende in this lode is abundant; galena and chalcopyrite also occur. The Moel-Ispri Mine (the Voel C lode) mined 66 tons of quartz for 88 ounces of gold, while the Prince of Wales Mine (the Voel A lode) has mined 20 tons of quartz for 63 ounces of gold. The outcrop of the Voel C lode may be traced for about 1 mile; at its western end it strikes 70° east of north; towards the east it strikes more and more northerly, finally becoming 40° east of north.

The two most southerly lodes of the Voel group occur in the Pen Rhos Beds; the most northerly runs along in the Vigra Beds for most of its observed length, but finally at its eastern extremity enters the Pen Rhos Beds. Greenstones occur frequently along the course of the veins, and the latter are most clearly defined in the neighbourhood of an igneous intrusion.

Cesailgwm or Wnion Lode.—This lode is well exposed on the slopes of the hill east of Cesailgwm-mawr, about 1½ miles up the stream which enters the Mawddach estuary near Borthwnog. Thence it may be traced at intervals for a distance of two-thirds of a mile to the west, and for a distance of about 2 miles to the east. Its general strike is 60° east of north, its dip never varies very much from the vertical. Its walls are well defined and consist of the Clogau and the Vigra Beds, near whose contact the lode always lies. Intrusive rocks occur at intervals along the course of the lode. The lode is usually 2 to 4 feet wide, often dwindling down, however, to mere veinlets. The vein is not heavily mineralized, but blende, galena, and chalcopyrite are found. In the years 1893–4 this lode produced 36 ounces of gold from 61 tons of stone.

In the Cesailgwm Valley, there is a lode parallel to and north of the Cesailgwm lode, which has been worked by the Borth Valley Gold Mining Company. Where opened up the lode formation is about 4 feet wide; it has a banded structure, being made up of 2 feet of poorly mineralized quartz, and a varying thickness, up to 2 feet, of mingled quartz and crushed country rock. Few mineral sulphides are to be seen; gold can be got by crushing and panning. This lode yielded 27 ounces of gold in 1906.

Blaen-y-cwm Group.—To the north of Blaen-y-cwm, near the head-waters of the Afon Wnion, there are numerous outcrops of small lodes, none of which extend far in strike. There are five lodes of this nature, all occurring in the Clogau Beds, though some extend from there into the Vigra Beds. Two of these lodes strike 60° east of north; two strike 15° south of east; one strikes 15° east of north.

All the veins of this group are similar to each other in formation and contents. Their width ranges from 3 feet downwards. The walls of the vein are poorly defined and usually there is no selvage of clay. The intrusive greenstones are seldom seen in association with this group. The lode matter contains a large admixture of shaly material derived from the walls; the quartz contains galena, blende, arsenopyrite and pyrites.

Cefn Coch Lode.—Next to the St. David's-Clogau and the

Gwyn-fynydd lodes, this is the most important lode in the Dolgelley belt. On the slopes of Cefn Coch Hill, and to the north-east, it strikes 45° east of north; to the south-west the strike becomes more northerly (25° east of north) for about half a mile; then on the slopes of Foel-ddu the lode regains its original strike; the total traceable outcrop amounts to about 2 miles.

Through the greater part of its length, the lode runs along the contact of the Clogau Slates and the Gamlan Shales. The topmost bed of the Gamlan group is here a coarse-grained quartzose grit, and at times the lode is represented by a series of stringers ramifying through this grit. Westward over the shoulder of the Cefn Coch Hill, the lode lies mostly in the Gamlan green shales and grits. Greenstone sills occur at intervals along the course of the lode and form one or both walls. This lode has been cited by earlier writers, e.g. Ramsay (12–15), as an instance of a vein forming the continuation of a greenstone dyke, but I have not been able to see anything more unusual than the pinching out of the lode close to a greenstone sill. The Cefn Coch lode branches frequently and is accompanied by parallel veins. The dip of the lode is towards the north-west, so that it very soon becomes confined to the Gamlan Beds below the surface. Its width varies from 6 inches up to 3 or 4 feet, occasionally swelling out into massive blebs of quartz, 10 to 12 feet thick. No clay selvage is present in the lode.

The quartz of the lode is not well mineralized, though the parts already worked out probably contained a much larger proportion of mineral than those now exposed. The most usual minerals in the quartz are blende and galena, and there are also chalcopyrite, pyrites, zincite, and gold. An analysis of the gold from this lode gave the following result: gold, 76·40 per cent.; silver, 22·70 per cent. Between the years 1863 and 1903, though the work has been of a most intermittent character, 2310 tons of quartz have produced 1193 ounces of gold.

Cae-mawr Lode.—This lode is seen on the hills on the western bank of the Mawddach near its confluence with the Afon-wen. The lode has little extent in strike; it strikes 15° south of east, and dips to the south at an inclination of 40° to the vertical. It intersects the Pen Rhos Beds of the Maentwrog, where its walls are clearly defined; the lode is wide, from 8 to 15 feet across. The metallic mineral contained in the quartz of the lode is of small amount and consists of chalcopyrite alone. In 1891 development work on this lode produced 10 tons of quartz for a return of 1 ounce of gold.

Dol-y-clochydd Lode.—Opposite the Precipice Walk, on the crags that overhang the Dolgelley–Trawsfynydd road, outcrops of white quartz have been opened up by a cross-cut. The lode can be traced satisfactorily only for the extent of the greenstone sill in which the cross-cut is driven, but a few isolated outcrops probably mark a continuation along the line of lode beyond the sill. The quartz of the lode contains some chalcopyrite; its strike is 45° east of north. The lode and its accompanying greenstone sill lie among the Pen Rhos Beds, while the isolated quartz outcrops range up into the lower part of the Ffestiniog group.

Glasdir Lode.—This lode has been worked extensively for copper, and like so many of the other copper veins of the district, it has been found to contain gold in addition. The lode is situated on the hills on the eastern bank of the Mawddach below its confluence with the Afon-wen. The lode is confined to the lower part of the Ffestiniog Flags, and its extension in strike is apparently limited. At the main workings the lode courses in a north-east direction, but its whole observed length of outcrop is not more than 100 yards. At the west end the lode appears to pinch quite out, and at this point a thin quartz-vein, running north and south, cuts across it; this vein has been worked a little, but is very barren. West of the quartz-vein, and running parallel to it, a large wide cross-course or fracture cuts the line of the main lode, and has smashed up the rocks for quite 80 yards; to the west of this, the main lode is lost.

The main lode is usually vertical, and its dip, though variable, is always great. It differs from all the other veins of the country in the almost entire absence of quartz. A good section is seen where the main cross-cut is driven to intersect the lode. Looking north-east, we see—(1) on the right, a fault-plane about 1 foot wide in which the country rock is much broken up and comminuted to pug and clay; (2) about 20 feet of green flags and shales, bent about, distorted, and slickensided. These flags and shales are impregnated with chalcopyrite to such an extent that they have been mined for some years for copper; the average tenor of the lode at this level is about 1 per cent. of copper, while in the deeper levels it rises and is said to approach 2 per cent. Blebs of quartz, usually white and poorly mineralized, occur throughout the impregnated flags, but they have no definite arrangement. In places the width of the impregnated zone or lode is as much as 50 feet; it has been opened up considerably in depth, but very little work has been done along the strike.

The deposit has been formed by cupriferous solutions, rising through the fissure on the south-east side of the lode, passing thence into the flags, and there depositing part of their copper contents. It will be remembered that the flags are bent and crushed about, so that they readily allow the passage of mineral solutions, and the diminution of pressure in them would probably facilitate the deposition of the minerals held in solution. The almost total absence of quartz is the unique feature of this lode. Besides chalcopyrite, the only metallic minerals I noticed in the lode were pyrites, bornite, and erubescite. In 1900 this lode produced 199½ ounces of gold. The copper concentrates generally assay about 1 ounce of gold to the ton.

Ffridd-goch Lode.—High up on the eastern bank of the Afon-wen, more than a mile above its confluence with the Mawddach, the Ffridd-goch lode strikes 5° east of north, and dips steeply (70°) to the eastward. It can be traced for about 1200 yards; it is confined throughout to the lower parts of the Ffestiniog Flags. At its southern end the lode runs along and through several greenstone sills, but further north the latter die out. At places the lode is accompanied by one or more parallel lodes. Where it has been opened up it is well defined, and commonly 3 feet in width. The quartz is poorly mineralized, pyrites is the most usual metallic mineral, a little chalcopyrite and pyrite being also present. Gold was obtained from this lode during the period 1896–1902, 109 tons of quartz being crushed for 105½ ounces of gold.

Ceunant-hyll Lodes.—The Ffridd-goch lode is crossed by the line of the Ceunant-hyll lodes, a set of two or three minor veins on which a small amount of development work has been done. Like the Ffridd-goch lodes these occur in the lower part of the Ffestiniog Flags, and are associated with large intrusions of a coarse-grained greenstone, which is in places amygdaloidal. The largest lode strikes 5° south of east, and can be seen for about 500 yards along the strike; its width is from 18 to 24 inches. There is also another lode, striking 65° south of east, and dipping much more steeply. The vein matter of these lodes is similar, and consists of crumbly pyritous quartz, containing a large amount of talc and chlorite, and a little chalcopyrite; gold also has been found here.

Dol-y-frwynog Lodes.—On the western bank of the Afon-wen, directly opposite the Ceunant-hyll lodes, is the southern extremity of the Dol-y-frwynog lodes. The main lode of these strikes 25° east of north, and has a course of at least 900 yards; it is accompanied by several parallel veins of variable extension in strike, the dip of all being approximately vertical. At the largest cross-cut there are five parallel lodes, ranging from 1 to 6 feet in thickness. To the north another lode has been worked to a great extent; the strike is 35° east of north, and gold was here associated with chalcopyrite and pyrites. The rocks traversed by these lodes are the Pen Rhos Beds of the Maentwrog. Greenstones occur along the course of the lodes, and have their ferro-magnesian constituent largely converted to talc and chlorite.

Cefn-deuddwr Lodes.—At the junction of the Afon Eden with the Mawddach, there are two parallel lodes striking 15° south of east, and dipping towards the north at an angle varying from 55° to 80°. They can be traced for only a short distance, along which they lie in the Vigra Beds of the Maentwrog, and cross in their course several greenstone sills. Chalcopyrite occurs in the quartz, galena and gold also occur in small quantities.

Tyddyn-Gwladys Lode.—About a mile above the Mawddach-Eden confluence, on the road to the Gwyn-fynydd Mine, several old levels and cross-cuts open up the Tyddyn-Gwladys lode; this strikes about 55° east of north, and dips from 60° to 80° towards the north-west. The outcrop of the lode lies in the Clogau or Menevian black slates, and passes through many sills of intrusive greenstone. In the places where the lode is now exposed, the quartz is white and poorly mineralized; the dominant metallic mineral is galena, for which, and the silver contained therein, the lode was mined. Other minerals seen in the lode-matter are blende, chalcopyrite, arsenopyrite, and pyrites. Gold has also been obtained from this lode, 7 ounces having been got in 1889.

Cwm-heisian Lode.—On the opposite bank of the Mawddach from the Tyddyn-Gwladys Mine, is the Cwm-heisian or Cwm-eisen lode, which strikes 10° south of east, and dips towards the north, from 70° up to practically a vertical position. The lode outcrop is much obscured by glacial drift; to the west it lies in the Vigra Beds, and towards the east in the Pen Rhos Beds. Very little greenstone is to be seen along the course of the vein. The levels by which the lode was opened have now fallen in; where the lode outcrops, the quartz is white and opaque, with very little mineral. Specimens from this lode are to be seen in the Museum of Practical Geology, Jermyn Street, and of these Maclaren has said (38, p. 453): "The invariable associate of the gold is zinc-blende, the latter being sometimes contemporaneous and sometimes prior in point of deposition; galena and pyrites also occur, and indeed the veins were originally worked as a silver-lead mine." The total reported output of this mine from 1860 to 1905 has been $12\frac{1}{2}$ ounces of gold from 50 tons of quartz. It is stated also that in the early days this mine gave two large returns, aggregating 318 ounces of gold from $457\frac{1}{2}$ tons of stone, but there are no figures to support this statement.

Gwyn-fynydd Lode.—On the southern flanks of the Moel Gwyn-fynydd, about half a mile north of the junction of the Afon Gain and the Mawddach, several disused levels and shafts mark the outcrop of the Gwyn-fynydd lode. Like the majority of the lodes of this district, it is found along with parallel companion lodes, as many as twenty of these having been passed through in the cross-cut which opens up the mine; one of these companion lodes is in places 20 feet thick, and is known as the Chidlaw lode. The strike of the Gwyn-fynydd vein is about 70° east of north, and the dip is towards the north, never flatter than 70°. The outcrop can be traced for a distance of about $1\frac{1}{2}$ miles; at its western end it cuts across the top of the Barmouth Grits, then through the whole of the Gamlan into the Clogau Beds. Here the outcrop is thrown to the south by the Afon Gain fault, which courses down from the north. The lode then continues through the Clogau Beds into the Vigra Beds, in which it terminates against the Gwyn-fynydd fault, on the eastern side of which it has not been picked up. The lode in its course cuts through sills of greenstone, but these are not numerous. The thickness of the lode is variable: in the parts where it has been worked (i.e. in the Clogau Beds) it is from 3 to 25 feet in width, to the west and to the east it may often be as thin as 2 or 3 feet. Often the lode includes large bodies of slate and shale. The lode material consists of very white quartz, with great patches of galena, pyrites, and chalcopyrite in finely granular aggregates. In addition to the above, orpiment, pyromorphite, and mimetite (40, p. 693), arsenopyrite and blende (38, p. 452) are said to occur. Gold has only been found at those places where the vein crosses the Clogau black beds. Where it occurs it is often in a very finely divided state; sometimes, however, it is massive and arranged as in irregular veinlets. During the period 1864–1907 this mine has produced 36,116 ounces of gold from 96,569 tons of stone; during certain periods (especially 1888–92) it has furnished practically all the gold output of Merionethshire.

Summary of the Auriferous Veins.

It is to be remarked that in the Dolgelley Gold-belt not a single auriferous vein is found in any formation lower than the Clogau or Menevian black slates. Some of the auriferous veins may extend into the Gamlan Beds, but they appear to lose their auriferous character. Again, no vein is known to be auriferous above the lower part of the Ffestiniog Flags. The only formations in this Dolgelley Gold-belt which are intersected by auriferous quartz-veins are the Menevian (Clogau), the Maentwrog (Vigra and Pen Rhos), and a small part of the Ffestiniog—a total thickness of about 3600 feet.

Throughout the gold-belt of Dolgelley the igneous intrusions (greenstones) are for the most part not of large extent; it is only the larger ones that are noted on the geological maps which accompany this paper; they are, however, very numerous, and the auriferous veins are found close to them, often, if not always, forming part of the wall or walls. The Dolgelley lodes appear to have no gossan; underground their characters appear to be similar to those they possess at the outcrop.

Reviewing the facts concerning the occurrence of the auriferous veins of Merionethshire, we may say—

(1) That the usual strike of the auriferous lodes is north-east and south-west, in some cases diverging to east and west, in others to north and south; the bulk, however, strike north-east and south-west.

(2) That there is no difference in mineral contents between the veins that range north-east and south-west and those that range east and west, or north and south.

(3) That auriferous veins are not found below the Clogau or Menevian Beds.

(4) That they occur only in black carbonaceous slates or shales, rich in pyrites.

(5) That they are associated always more or less intimately with igneous intrusions.

(6) That the lode material consists usually of quartz, often with calcite and impregnated country rock. In one case (Glasdir) the whole material of the lode consists of these impregnated shales and flags.

(7) That the most usual minerals associated with the gold are blende (sphalerite), chalcopyrite, galena, and pyrites.

(8) That the gold is usually coarse, granular or aggregated, and seldom shows crystalline faces; rarely it occurs finely disseminated through the quartz.

(9) That the distribution of the gold in the lodes is very capricious, and is not known to follow any regular law, though it appears most possible that it may be regulated by the fractures or cross-courses which intersect the lodes. Whatever the cause of the rich pockets, on them depends the future success of the mines, and until the law regulating their distribution is discovered, the mining of these lodes will always entail even more uncertainty than that which is usually associated with any gold-mining. It seems that it might be advisable, in the case of those mines now at work, to investigate as far as possible the influence that these cross-courses have on the distribution of the gold in the lodes.

(10) That in the upper portions of these lodes there is no conspicuous belt of ordinary weathering, though as work on these lodes has not

proceeded to any great depth it is possible that the whole of the lodes so far mined may be in part enriched by secondary enrichment.

Genesis of the Auriferous Veins.

The general idea of the genesis of auriferous veins is that they were filled by waters carrying gold and other minerals in solution; these waters rose from below through fissures and deposited their metallic contents in those fissures owing to—

(1) Decrease of temperature, which caused the solutions to become supersaturated and to deposit part of their contained minerals.

(2) Decrease of pressure which acted similarly.

(3) Reactions between the ascending waters and other solutions which entered the fissure along its course; a common precipitant for gold, which is also a common substance underground, is ferrous sulphate, and another is carbonaceous matter.

(4) Reactions between the ascending waters and the solid material forming the walls of the lodes.

Subsequently the lode so formed was subjected to a process of secondary enrichment, which, by solution and re-deposition of the gold content, caused a relative enrichment of the upper portions of the lode.

Applying these general principles to the Dolgelley Gold-belt, there is to be remarked, on the one hand the total absence below the Clogau horizon of any black or carbonaceous bed, and on the other the total absence of any auriferous vein below that horizon. It appears that the solutions rising in fissures through the Lower Cambrian rocks were affected only by decrease of temperature and pressure, which were not, however, sufficient to cause any important deposition of gold. At the horizon of the Clogau Beds, however, solutions entered from the wall-rocks, containing ferrous sulphate and organic matter, in both of which the Clogau Beds are rich; interactions between the two solutions caused a precipitation of the gold. As the solutions passed upwards into the Maentwrog Beds, more and similar solutions would enter, and gold would be deposited there also. The greatest amount of gold, however, would probably be deposited at the Clogau horizon. This theory tallies with what we know of the occurrence of the gold in the field; far and away the bulk of the gold has been obtained from the two lodes whose outcrops are in the black Clogau Beds.

The most ready channels for solutions to enter would be through cross-fractures, and at these points we might expect to find greater deposition of the gold. So far, we only know of this having occurred in one instance at the St. David's lode and one at the Panorama lode; but the paucity of examples may be due to deficiency of observation, for no one appears to have been on the look out for cross-courses and their possible effects.

The almost constant association of the auriferous beds with intrusive greenstones means only, I think, that the heat of the magma gave the percolating waters during the period of the intrusion a greater chemical activity, and rendered them capable of dissolving out and holding in solution more substances with which they came in contact.

Secondary enrichment is in this district only of slight importance; there is an absence of oxidized minerals in the outcrops, and there is an absence of the minerals which are usually considered to be characteristic of a zone of secondary enrichment.

The association of minerals found in the lodes, and especially the pyrrhotite, suggests deep-seated lode formations, i.e. lodes formed at some considerable distance below the then existing land surface, but which, owing to denudation, are nearer to the land surface existing at the present day.

With regard to the existence of small traces of gold in the country rock of these lodes, I was unable to determine whether such existed or not. Maclaren (38, p. 508) had made some assays, and had found minute traces (·0007 grain of gold per ton) in some of the country rocks; but it is not clear whether such gold, even if it could satisfactorily be proved to exist in the country rock, had not really been introduced into the country rock from the veins.

From this account of the gold veins of the Dolgelley Gold-belt, it may be inferred as most probable that as the mines working on lodes that outcrop in the black Clogau Beds work down below that horizon they will leave behind them the rich pockets of gold. Although it is possible that a cross-course conveying gold precipitants may cause the formation of a pocket at this lower depth, still it is not very likely. Those mines which operate on lodes outcropping in the Vigra and higher beds will, if they work down to the Clogau horizon, improve their chances of striking rich pockets of gold; it is possible, however, that they would not survive to work down to that depth. Where the lodes cut across the Clogau Beds it is most probable that the rich pockets are dependent for their position on the occurrences of cross-courses.

In examining the lodes underground it is difficult to acquire information regarding the associations of the richer pockets. In most cases it is no longer possible to examine the places where the richer pockets were found. Really, such examination could only satisfactorily be carried out by one who constantly visits the working faces and notes down all particulars which may have a possible bearing on the occurrence of these greatly coveted bonanzas. In an American mine this would be done by the mine geologist, whose special duty it is to collect geological data regarding the ore-deposits; but as such an official does not exist in English mines we can only hope that a substitute may be found in one of the regular mine officials, whose duty causes him to inspect the working faces day by day, and whose love of research prompts him to record all the geological facts that come within his observation.

Professor Lapworth, of Birmingham University, has aided me greatly in the preparation of this paper: he has spent many days with me in the field; he has shown me through the sequence of beds; he has given me the benefit of his experience in the laboratory and office work connected with this paper: for all of these aids and also for his never varying encouragement, I am truly grateful. To the officials of the St. David's Gold Mining Company, and especially to Mr. Nicholls, the general manager, I am very much

indebted for opportunities of visiting the lodes underground, and also for a vast amount of information regarding the occurrence of those richer pockets of gold, which they are always in the hope of finding.

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VI.—On the Stratigraphical Distribution of the Inferior-Oolite Vertebrates of the Cotteswold Hills and the Bath–Doulting District.

By L. Richardson, F.R.S.E., F.G.S.

Vertebrate-remains are by no means abundant in the Inferior-Oolite rocks of the Cotteswold Hills and Bath–Doulting District. Mr. H. B. Woodward, F.R.S., has written—

"The Inferior Oolite Series has yielded a rich and varied Invertebrate fauna, but the remains of Saurians and Fishes are very rare.

"The Reptilia that have been found include *Megalosaurus* and *Steneosaurus*, and the Fishes are represented by *Hybodus*, *Strophodus*, etc."

At the end of the work from which the above quotation is taken is a list of the vertebrate-remains which had been collected up to that year, namely, 1894.[1]

In 1904 I gave a list of the vertebrate-remains which had been recorded from the Cheltenham district,[2] and, except for the record for vertebræ and bones of ? *Ichthyosaurus* from Leckhampton and Sudeley Hills (on the authority of James Buckman & H. E. Strickland, and the more precise stratigraphical location of certain of the other recorded remains), my list was the same as that given in the Geological Survey Memoir mentioned above.

The following list is by no means a lengthy one, but as it embodies the results of quite ten years' collecting on my own part, and considerably longer on Mr. Charles Upton's part, it will be at once understood that vertebrate-remains are by no means common in the Inferior-Oolite rocks.

List of Vertebrate-Remains from the Inferior-Oolite of the Cotteswold Hills and Bath-Doulting District.

(*Those distinguished by an asterisk are in the Author's collection.*)

REPTILIA.

Dinosauria.

Megalosaurus Bucklandi, von Meyer. Lower Freestone (Hemera *Murchisonæ*). Aalenian.

Crocodilia.

Steneosaurus megistorhynchus (Deslongchamps). "Fragment of maxillary rostrum, showing three dental alveoli." "Gryphite-Grit" (*Sonniniæ*). Bajocian.

(*Vide* R. Lydekker, *Cat. Fossil Reptilia in the Brit. Mus.*, pt. i, 1888, p. 116.)

*? *Steneosaurus* sp. Reptilian jaw probably of *Steneosaurus*. *Witchellia*-Grit (*Witchelliæ*). Bajocian. Cold Comfort, near Cheltenham.

Ichthyopterygia.

Ichthyosauria.

? *Ichthyosaurus* sp. Vertebræ, etc. ? Bajocian. Leckhampton and Sudeley Hills.

(*Vide* James Buckman & H. E. Strickland, 2nd ed. of Murchison's *Outline of the Geology of the Neighbourhood of Cheltenham*, p. 80.)

[1] "The Jurassic Rocks of Britain—The Lower Oolitic Rocks of England (Yorkshire excepted)": Mem. Geol. Surv., vol. iv (1894), pp. 519–22.

[2] *A Handbook of the Geology of Cheltenham* (1904), p. 230.

SAUROPTERYGIA.

Plesiosauria.

* ? *Plesiosaurus* sp. Tooth. Lower *Trigonia*-Grit (*discitæ*). Bajocian. Frith Quarry, near Stroud.

Professor S. H. Reynolds and Dr. C. W. Andrews both state that this tooth is "Plesiosaurian in type".

* ? *Pliosaurus* sp. Two teeth. Top of Lower *Trigonia*-Grit or bottom of *Buckmani*-Grit (*discitæ*). Bajocian.

Professor S. H. Reynolds states that these teeth "are exactly like Pliosaurian teeth in the British Museum"—an identification confirmed by Dr. C. W. Andrews.

A piece of bone 6 inches long was obtained from the Gryphite-Grit of the west side of the Slad Valley, Stroud, by Mr. C. Upton.

PISCES.

ELASMOBRANCHEI.

Selachii.

Asteracanthus. See *Strophodus.*

Strophodus. *General Note.*—The teeth called *Strophodus* include two species: one in which the crown is flat (*S. magnus*, Ag.), and the other in which it is considerably elevated, and the tooth itself long and narrow (*S. tenuis*, Ag.). Satisfactory figures of these species will be found in the *Catalogue of the Fossil Fishes in the British Museum*, pt. i (1889), pl. xv, figs. 2, 3, and 4–8. The teeth which have been named *S. reticulatus* are now definitely known to belong to *Asteracanthus ornatissimus*, Ag., and are very differently ornamented and keeled.

S. magnus, Agassiz. Teeth. Aalenian, Bajocian, and Bathonian.

RECORDS: *Clypeus*-Grit or Doulting Beds. — *Harford Bridge (near Bourton-on-the-Water); *Birdlip Hill; *Slad Valley (near Stroud); *Rodborough Hill; *Soundborough Farm (near Andoversford); Quarry seven-eighths of a mile east of Paulton Church (near Radstock, Somerset); and *Doulting.

Upper *Trigonia*-Grit.—*Holwell (near Frome: "*Acanthothyris-spinosa*-Bed"); and *Maes Knoll, Dundry (near Bristol: "Conglomerate-Bed").

Notgrove Freestone.—*Belas Knap, near Winchcombe.

Buckmani-Grit.—*Tuffley's Quarry, near the Air-Balloon Inn, between Cheltenham and Birdlip.

Base of Pea-Grit or top of Lower Limestone.—*Huddingknoll Hill, near Painswick.

S. tenuis, Agassiz. Teeth. Bajocian and Bathonian.

RECORDS: *Clypeus*-Grit or Doulting Beds. — *Doulting; *Foss-Way Quarry, near Radstock.

Upper *Trigonia*-Grit.—*Wellow, near Radstock ("Conglomerate-Bed").

Gryphite-Grit.—*Kimsbury Castle (*teste* C. Upton).

HOLOCEPHALI.

Myriacanthus sp. Fragments of palatine teeth. Identified by Dr. A. Smith Woodward. Inferior-Oolite. Cleeve Hill, near Cheltenham.

Remains of this genus of Chimæroid fish *have not been recorded before from the Middle Jurassic*: only from the Lias and Kimmeridgian (*vide* Dr. A. Smith Woodward, Quart. Journ. Geol. Soc., vol. lxii, 1906, pp. 1–4, and pl. i; *Brit. Mus. Cat. Fossil Fishes*, pt. ii, 1891, p. 43). Unfortunately the fragments from Cleeve Hill were not found *in situ.*

? *Fish-teeth.*—Mr. Charles Upton found amongst the micro-organisms of the Upper Coral-Bed (*Truellei*-hemera) a number of minute teeth not unlike those from the Rhætic which are generally called "*Saurichthys acuminatus*", only much smaller. Also he obtained a minute round *Lepidotus*-like tooth.

? *Fish-remains in the Scissum-Beds.*—Brodie, writing of the beds at Leckhampton Hill (Quart. Journ. Geol. Soc., vol. vii, 1851, pp. 208–12), which are now called the *Scissum*-Beds, observes: "Bones, scales, Coprolites and teeth of Fish are dispersed throughout the mass, and may be most readily distinguished on the surface." At Crickley Hill the *Scissum*-Beds reveal on their weathered surfaces, mixed up with the sand-grains and shell-debris, innumerable black particles, which prove to be minute phosphatic bodies. These may be the objects to which Brodie refers, but it is impossible to identify them.

The Inferior-Oolite Vertebrates of no value for the purposes of minute zoning.

From the above list it will be observed that the fish-teeth called *Strophodus* are commonest in the Top-Beds (and especially in the *Clypeus*-Grit); the Reptilian remains in the "Intervening-Beds"; while the Freestone Series (except at Huddingknoll, near Painswick, where *Strophodus* teeth are very common) contains very few vertebrate-remains indeed. The Upper Coral-Bed has yielded a few, but unfortunately indeterminate, teeth, although probably piscine.

Except, then, that the flat *Strophodus* teeth predominate in the Top-Beds, the little acuminate ? fish-teeth in the Upper Coral-Bed, and the reptilian remains in the Intervening-Beds, the Inferior-Oolite vertebrates afford little assistance in subdividing the series and are useless for minute zoning purposes.

VII.—Note on a further extension of the 'Transition-bed' and Crinoidal Limestone Band in the Middle Lias of Leicestershire.

By A. R. Horwood, Leicester Museum.

ALLUSION has been made in a previous paper[1] to the crinoidal limestone band and Transition-bed at Billesdon Coplow, and to the existence of the former at Tilton Hill near Lowesby Station. At the latter place, though the Transition-bed is not exposed in situ, the position of the crinoidal limestone bed (after making full allowance for Drift deposits), is low enough, with beds normally horizontal or with a slight easterly dip, to adduce without any doubt the extension of the Transition-bed above it at this point. Thus the crinoidal limestone band had been traced at three points — Tilton (*vide* Wilson, ibid.),[2] Billesdon Coplow, Tilton Hill—in the southern portion of the exposed area of the Rock-bed in Leicestershire, up to the time when the second paper, contributed by the author dealing with this bed in Leicestershire, was written. That is to say, it had only been found in the southern series of bold escarpments or spurs into which the district is divided. For the Twyford brook, running more or less west and east, divides the two series to which reference is directly made into a northern and a southern series, or if we include the Belvoir, Stathern, Eastwell, Holwell, and Waltham tract still more to the north, into three, with a central tract north of the Twyford brook.

[1] Geol. Mag., 1910, p. 177; 1907, p. 462.
[2] Op. cit., 1886, p. 296 et seqq.

Thus the southern portion which is free from Drift forms a series of winding sinuous escarpments right away from the Coplow to the south at Neville Holt, Hallaton, Medbourne, broken here and there by valleys now partially filled with Drift, or eroded by streams. And it has, furthermore, been lifted up by the Tilton–Loddington fault, so that some portion is now considerably out of its original position to the west.

North of the Twyford brook the Marlstone in this central tract commences to form a bold feature to the west at Burrough-on-the-Hill, and in a less degree at Thorpe Satchville—but it forms a more continuous range of hills to the north-east of Burrough, where it constitutes the backbone of the ridge and connecting spurs, all classic hunting-ground, which stretch from Somerby, Pickwell, Knossington to Ranksborough and Whissendine—whilst near Owston it bends round to join the Tilton mass to the south. But except at Burrough Hill and a few other points the Rock-bed is greatly obscured by Drift, so that sections are few and far between. This, then, may be termed the central tract.

In turn the most northerly Leicestershire *massif* is separated from the central tract by a line somewhat to the north of, but more or less parallel with, the Saxby and Bourne line from west to east, and extending from Holwell, Eastwell, Waltham, right up to Belvoir. It is connected by the Harby Hills, striking northwards from Long Clawson to Stathern, in the far north of the county.

It is at Burrough-on-the-Hill, a place noted for its fine Roman encampment, which was earlier too probably a Celtic stronghold (and where now the Spring Parliamentary Steeplechases are yearly held), that the new discovery of the crinoidal limestone band has been made by the writer since the first paper (Geol. Mag., April, 1910, p. 177) was in hand. The discovery is the more important as it relates to the central portion of the Marlstone outcrop, separated from the southern by a considerable distance.

Though I had searched carefully for indications of this very characteristic bed (band 4 at Wildbore's Lodge, Robin-a-Tiptoes, near Tilton[1]) at Burrough-on-the-Hill, I had until recently failed to find any indication of it. Except for an old trial-hole and obscure exposures, or slips covered with talus, no good section really existed on this extensive and well-known hill.[2] But in looking over some débris fallen from the higher ground on the northern extremity of the ridge, I discovered a curiously attenuated and modified form of the bed. This consisted of a thin sandy ferruginous rock with rounded and occasionally angular pebbles or inclusions of green and brown rock (chiefly Marlstone) and a few joints of crinoids. Evidently this was a conglomerate or brecciated conglomerate which represented the crinoidal limestone band at its western margin, at a period when that very constant, continuous stratum was being gradually elevated from the pelagic depths in which the normal highly calcareous band was being laid down. The marginal portion of this band lying in

[1] *Vide* J. W. Judd, "Geology of Rutland, etc.": Mem. Geol. Surv., 1875, p. 68. This bed may possibly be band 2 at Billesdon Brickyard (ibid., p. 69).

[2] Since previous visits a small quarry has been opened, but in lower beds.

a synclinal trough would naturally first be exposed to waves and littoral conditions generally, and whilst retaining something of its original character (as shown by the scattered crinoid fragments) would also include pieces of sediment derived from littoral sources, and receive later littoral detritus; and if above water or near sea-level, rolled fragments would be mixed up with the pelagic matter.

The fossils, indeed, found in the sandy ferruginous mass were those of beds lower down, e.g. *Pecten lunularis, Lima pectinoides*, Belemnites, etc. Whilst admitting that this rock, not being found in situ, might possibly represent our bed C at Billesdon Coplow, we consider at present it represents a higher series; but however that may be, subsequent discovery, stimulated by this find, is amply sufficient to support the correlation advanced later in this paper.

The discovery of this abnormal rock was, in fact, a clue in itself, and though not found in situ indicated the close proximity of a similar or more normal band. Nor was I disappointed in the quest, for slightly higher up, after finding a loose slab of crinoidal limestone, of a browner colour than usual, in a small covert, a shallow overgrown excavation flanking a hedge-row revealed actual traces of the real crinoidal limestone band in situ. Here again, however, the deposit was also abnormal, for instead of constituting a single thick well-marked stratum it was split up into two beds divided by 10 inches of sandy ferruginous rock, with a conjoint thickness of 3 to 4 inches.

We have thus evidence of the further extension of the crinoidal limestone band from the southern area to the northern or the central portion, indicated by an exceptional but highly interesting and instructive rock. It may be that this band has assumed the character of the thinner band (bed C) in the Billesdon Coplow section,[1] where it is broken up and irregular, in which case it would indicate a zone just below the bed B, or crinoidal limestone band horizon, if identical; but, apart from their different lithological composition, differing as they do in purity of contents, the Burrough crinoidal band is regular in extent, though attenuated. It dips at an angle of somewhat more than 10° to the south-east (just at this point), and may thus represent just the western margin of the Middle Liassic sea. The conglomeratic band, whether equivalent to bed B or C at the Coplow, is an example of shore conditions, and laid down to the west, being now displaced by earlier quarrying and weathering.

In thus establishing the original continuity of the crinoidal limestone band between the central and southern Marlstone tracts in Leicestershire we may, furthermore, venture to predict the existence of the 'Transition-bed' at the same locality, for the crinoidal band is sufficiently below the top of the hill to allow this, as at Tilton Hill, being quite 5 feet below the surface on the higher ground. So that though palæontological evidence, which alone is conclusive, is not here forthcoming, owing to the character of the section, yet stratigraphic evidence is undoubtedly in favour of its existence.

The section, in so far as it is possible to indicate its thickness, is as follows:—

[1] Trans. Northants Nat. Hist. Soc., 1907, p. 108.

		ft.	in.
A.	Broken ferruginous marly rock, sandy and much weathered. Probably representing 'Transition-bed' (bed A at Billesdon Coplow) . .	2	6
B.	Thickly bedded sandy ferruginous rock with a seam of crinoidal limestone parted by 10 inches of sandy rock (bed B at Billesdon Coplow)	2	0
C.	Blue, green, or brown marly ferruginous, laminated beds, with Belemnites, *Pecten*, *Terebratula*, *Rhynchonella*, base not seen .	1	6
(?)	Bed C, Billesdon Coplow.		
		6	0

In so far, then, as Leicestershire is concerned the existence of the Transition-bed may be postulated in both the southern and the central tracts, whilst up to the present, though I have made search for it, it has not been met with in the northern tract. But less hopeful of finding it at Burrough as I was when it turned up at Tilton Hill, after its discovery at Billesdon Coplow, its present further extension may be said to give additional reason for prophesying its discovery in the future in the more extensive but less easily accessible district between Belvoir and Melton, where there is a thick covering of Drift.

Note.—Since my previous paper on the occurrence of aragonite in the Middle Lias of Leicestershire was published I find that aragonite has been discovered in the Cheltenham district at Churchdown,[1] Gloucs. This in no way minimizes, I think, the interest attaching to my own observations, which devolved rather upon the mode of formation and composition of different parts of the Marlstone, and their physical history, rather than upon the bare record of the occurrence of this mineral itself, which is not uncommon as a shell-substance in all districts. And whilst the Leicestershire specimens are not the first recorded examples they add to the significance of the occurrence elsewhere by suggesting a definite horizon at which the general temperature of the waters of the sea in the Marlstone epoch were much warmer over a wide area, than either above or below, and not merely locally at one spot. The extension of range, moreover, of aragonite in the Middle Lias, as a mineral pure and simple, is in itself assuredly of some interest.

I have to make a correction in the same paper, having inadvertently written Barnstone for Wartnaby in reference to the occurrence of striæ on the surface of the rock-bed. In the recently published Survey memoir on the Melton Mowbray district, a photograph and diagram of the quarry where these striæ were noticed are given (plate iii and fig. 6).

In the same memoir (p. 40) it is stated that no specimens of *Amaltheus margaritatus* have actually been found in the district surveyed (Sheet 142). It may be worth while mentioning here that this zone-fossil was found by me in 1908 in that area, not in situ but doubtless derived from a local source, on the mineral line which runs down from White Lodge to the Great Northern Railway south of Harby and Stathern Station. It occurred below the rock-bed outcrop and within the area of the *margaritatus* shales, so was doubtless derived from them at this place.

[1] F. Smithe, Proc. Cotteswold Club, vol. vi, p. 349; Mitchell, *Geology of Stroud*, p. 17.

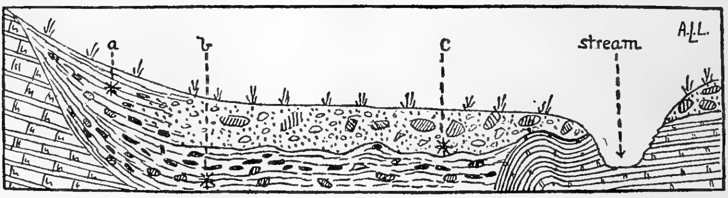
VIII.—On a Glacial Drift at Marros, near Amroth.

By A. L. Leach.

ONE mile and a half east of Amroth a small valley which opens on the coast of Carmarthen Bay at Marros shows drift deposits of much interest. The valley itself is noteworthy. Like several others in the vicinity it is deeply cut in comparison with its width; the gradient of the valley sides is as high as 1 in 2, and the depth below the bordering hills is not less than 300 feet. The stream, which now drains the valley, rises on Marros Mountain, barely 2 miles from the shore, and flows down the main dip-slope of the Coal-measures, which here are greatly disturbed by folds and faults.

The pre-Glacial origin of the valley is suggested by its depth, and fully confirmed by the nature of the drifts, which cover the floor and are well displayed on the shore, where the sea has cut into these deposits and formed a vertical section, 200 feet long, extending from side to side of the valley. Other sections are shown in the banks of the stream, which by excavating a new channel through the drifts has cut down to the pre-Glacial rock-floor. But although the stream has reached the rock it does not flow along the lowest part of the pre-Glacial valley; it has cut a new channel in the rock several feet above the base of the drifts and, as will be shown later, its post-Glacial erosion may be estimated. The chief interest of this small valley arises from the exceptional clearness of the relation between the drifts and the valley-floor. The larger valleys to the west of Marros are choked with recent alluvial deposits, and their mouths are blocked by sand-dunes and storm-beaches, which, except in one case, completely hide any glacial deposits that may be present.

The Marros Valley is excavated in shales and grits of the Coal-measures. A small anticlinal fold rises under the glacial gravel in the mouth of the valley, and probably a fault is concealed by the thick drift deposit.



Section of the Drifts at Marros, near Amroth: *a*, newer stony loam; *b*, older stony loam; *c*, glacial gravel. Length of section 200 feet. The thickness of the drifts is exaggerated.

The drift section shows at the bottom a stony loam composed of decayed local rocks, in which are embedded angular blocks and slabs derived from the slope of grits and shales against which it rests. Close to the west side of the valley this deposit is nearly 20 feet thick, but after it passes under the glacial gravel its base, being hidden by a storm-beach, cannot be seen, and the thickness shown in the cliff does not exceed 3 or 4 feet. The glacial gravel rests upon an uneven surface of this stony loam, except on the eastern side, where it rests on the solid rock. It is a very coarse gravel, containing brown and red sandstones and red marls (Old Red Sandstone), brown grits and shales, yellow grits and quartzites (Coal-measures and Millstone Grit), with large well-worn boulders of quartz and pale quartzite. The stones are closely packed in a small gravel composed of similar materials. The thickness of the gravel is from 4 to 6 feet, its base resting on an uneven surface of the stony loam described above. The source of some of the rocks is indicated above. All the Old Red Sandstone debris is derived from rocks not only outside the basin of the Marros stream but separated from it by a deep valley in the Carboniferous Limestone: the quartz boulders are also erratics, and an igneous boulder which was found in situ in the gravel appears to be derived from some of the intrusive igneous rocks of Pembrokeshire, at least 12 or 15 miles to the north. A considerable proportion of this gravel has therefore been derived from beyond the present basin of the stream, and some of it has apparently come from the north-western side of the broad valley of the Taf. The glacial origin of the gravel is thus proved, since no agent except moving ice seems adequate to transport material into the Marros Valley over one, if not over two watersheds. At its western edge the glacial gravel is overlain by stony loam similar to that which underlies the gravel.

In their formation these drifts belong to two classes; the bottom stony loam appears to be a talus of purely local origin accumulated against the slopes of the valley during severe climatic conditions and subsequently spread out over the floor of the valley. The glacial gravel is probably not a true moraine, but water-deposited glacial debris formed as an 'outwash gravel', the material being derived from moraines higher up the valley or on the hills to the north. There is no lack of evidence of the glaciation of the district. Glacial drifts and numerous erratic boulders occur on these hills and extend many miles to the south-west in Pembrokeshire.[1] On "the ridge south-east of Marros" Dr. Strahan[2] noted a well-glaciated block of Millstone Grit.

The formation of the Marros Valley gravel as an 'outwash' deposited by glacial torrents will explain the non-occurrence of striated and scratched stones which were vainly sought for in the deposit. Any such striations would have been obliterated during the formation of the gravel by torrential streams.

A passing reference was made to the present channel of the stream which has cut down through the drifts to the rock, but, in the mouth of the valley at least, has not reached the lowest part of the pre-glacial floor. Deflected to the east side by the drift, it has cut a shallow channel along the rock slope on that side, several feet probably above the old stream-course, and now falls to the beach in a small cascade. The depth of this new channel, about 3 feet, may be taken as an indication of the erosion accomplished by the stream mainly in the post-Glacial period.

[1] R. H. Chandler, "On some Unrecorded Erratic Boulders in South Pembrokeshire": Geol. Mag., Dec. V, Vol. VI, No. 539, May, 1909.

[2] *Sum. Prog. Geol. Survey*, 1903.

NOTICES OF MEMOIRS.

The Southernmost Glaciation in the United States. By D. W. Johnson.[1]

In a recent number of *Science*[2] H. W. Fairbanks and E. P. Carey report evidences of "Glaciation in the San Bernardino Range, California", in latitude about 34° 7′ N. Concerning this interesting discovery the writer says: "It has hitherto been assumed that the southernmost point of glaciation in the United States was in the Sierra Nevadas, nearly 200 miles to the north" (north of latitude 36° N.). If their observations are correct they have found the most southern instance of satisfactory evidence of glaciation in this country, so far as I recall; but there are several records of glaciation farther south than the point in the Sierra Nevada referred to by them. Brief references to these may be of interest.

Science for November 22, 1901,[3] contained a "Note on the Extinct Glaciers of New Mexico and Arizona", by George H. Stone, in which he reported evidences of glaciation in one of the Rocky Mountain Ranges "as far south in New Mexico as a point not far north of Santa Fé" (latitude about 35° 41′). In a later paragraph we read—

"The farthest south and west I have found traces of extinct glaciers is at Prescott, Arizona. Around Prescott are numerous moraines. The highest part of the névé of this glacier could not have been much above 9000 feet. The central part of the glacier is approximately in N. lat. 34° 30′. The occurrence of an ancient glacier so far south as this was probably due to a very great snowfall owing to the proximity of the ocean . . . Probably there were then small glaciers in some of the cirques of northern exposure among the mountains directly south-east of Prescott."

R. D. Salisbury published an article on "Glacial Work in the Western Mountains in 1901", in vol. ix of the *Journal of Geology*, 1901. Beginning with p. 728 is a brief description of glacial features in the mountains near Santa Fé, between 35° 45′ and 36° North latitude. Some fifty cirques were found, and about eighty ponds and lakelets. One of the glaciers had a length of 7 miles. Moraines, striæ, and roches moutonnées were observed. In 1902 I had an opportunity to visit this same region, and I entertain no doubt as to the ample proof of local glaciation in those mountains.

In the *Journal of Geology* for 1905[4] is a paper by Wallace W. Atwood on the "Glaciation of San Francisco Mountain, Arizona". This writer describes and figures terminal and lateral moraines, and an outwash plain, and reports the occurrence of striated boulders and polished and grooved bedrock. I have briefly mentioned evidences of glaciation on this same peak, attributing a somewhat greater amount of erosive work to the glacier than is recognized by Atwood, and mentioning what I then believed to be a terminal moraine located near the mouth of a cirque.[5] The latitude of San Francisco Mountain is about 35° 21′ N.

[1] Reprinted from *Science*, n.s., vol. xxxi, No. 789, pp. 218–20, February 11, 1910.
[2] January 7, 1910. [3] Vol. xiv, p. 798. [4] Vol. xiii, p. 276.
[5] *Technology Quarterly*, 1906, vol. xix, p. 410.

F. J. H. Merrill reports in *Science* for July, 1906,[1] "Evidences of Glaciation in Southern Arizona and Northern Sonora." In the vicinity of Nogales, and elsewhere, were found deposits which he believed to be of glacial origin, while the surface had "the rolling topography and pitted surface of a moraine". Nogales is in latitude 31° 20′ N.

The above references may be but a partial list of the published reports of glaciation south of the point in the Sierra Nevada referred to by Fairbanks and Carey; I have made no effort to prepare a complete list. Of these reports, the one on glaciation near Nogales is the most striking, because of the low latitude and low altitude in which the deposits are found. The evidence as reported does not appear sufficiently convincing, in view of the strong probabilities against the occurrence of glacial deposits in the region in question. Merrill's descriptions suggest a landslide origin for the deposits which he took to be glacial. With reference to the glaciation of San Francisco Mountain I wish to add the following paragraphs.

On my visit to San Francisco Mountain I ascended the volcano by the north-west slope, and I descended into the north-western part of the 'crater'. I was impressed with the cirque-like form of the depression, and came to the conclusion that the original crater had been destroyed by stream and glacial erosion, and that the encircling cliffs were to be regarded as cirque-walls rather than as crater-walls. The great central depression of the volcano consisted of several more or less distinct cirques uniting down-stream. Near the mouth of one of these was what I interpreted as a crescentic terminal moraine, rising 150 feet or more above the valley floor. But there were certain associated features which puzzled me at the time. Up-stream from the supposed moraine the floor of the cirque appeared to be deeply buried by an accumulation of rock débris which was generally as high as, and near the head of the cirque distinctly higher than, the morainal ridge. This débris was in places, especially near the marginal walls arranged in parallel ridges trending with the axis of the valley; and in the depressions between the ridges were patches of snow and some small ponds. Thus the moraine had a steep frontal slope, but at the back merged with the ridged rock débris, which rose to still higher levels. There were some depressions in the rock débris, 25 to 40 feet deep, which I took to be ice-block holes. No bedrock was seen in the cirque floor.

During the recent meeting of the Geological Society of America, Professor H. B. Patton, of Boulder, Colorado, exhibited some photographs of the rock streams of Veta Mountain, Colorado. One of these photographs showed the high and steep front terminus of a rock stream, and resembled very closely the front slope of the supposed moraine in the San Francisco cirque. Others of his pictures showed the longitudinal parallel ridges which characterize some rock streams, with bands of snow lying in the hollows between the ridges, just as was the case in the San Francisco cirque at the time of my visit. If the concentric wave-like ridges pictured by Howe[2] were present in the San Francisco deposits, I did not notice them.

[1] Vol. xxiv, p. 116.

[2] "Landslides of the San Juan Mountains": U.S.G.S. Professional Paper, No. 67.

I am inclined to believe that the features which puzzled me at the time of my visit may have been due to landslides or rock streams. This does not mean that the depression in which the features occur is not a glacial cirque, nor that the moraines reported by Atwood are not true moraines. It simply means that I am not wholly satisfied with the evidence of glaciation as reported by myself. It would seem that the possibility of a landslide of rock-stream origin for features apparently due to glaciation must be carefully considered, especially when glaciation in doubtful localities is involved.

REVIEWS.

I.—Crystalline Structure and Chemical Constitution. By A. E. H. Tutton, D.Sc., M.A. (Oxon.), F.R.S., A.R.C.Sc. (Lond.). pp. viii+204, with 54 figures in the text. London: Macmillan and Co., 1910. Price 5*s.* net.

Dr. TUTTON'S reputation for crystallographical research stands so high that the announcement of a book from his pen on a subject of such primary importance as crystalline structure and chemical constitution cannot fail to awaken general interest among those interested in crystallography, but we fear that on realizing the true scope of the book many readers will feel considerable disappointment. Far from discussing the wide subject comprehended by the title of the book, Dr. Tutton confines himself entirely to a comparatively small section of it, and, moreover, to his own contributions to that section. Everyone may not have seen the prospectus relative to the series of science monographs of which this is the first volume, and may not be aware of the intention of the publishers that "each volume will be unique, inasmuch as the author will describe chiefly his own contributions to the specific subject of scientific research with which it deals": to prevent misunderstanding it is desirable that this restriction should appear on the title-page. This volume, at least, cannot pretend to be at all an adequate discussion of the subject with which it is supposed to deal.

On the other hand, the book provides an admirable summary of the fine series of investigations upon which Dr. Tutton has for the past twenty years been engaged, and the reader may obtain a clear idea of the nature and results of the research without the labour of hunting up the original papers in the various periodicals in which they appeared. The most casual reader cannot fail to be struck with the pains taken to ensure that the apparatus and the crystals used in the investigations were of the most perfect quality obtainable, and with the indefatigability that has characterized the observational work. In the introductory pages the author, doubtless carried away by his enthusiasm, has depicted in unduly dark colours the state of the knowledge of isomorphism obtaining at the time he commenced his researches. The book is well printed, and its value is enhanced by several excellent illustrations, in one of which the author is seen in the act of grinding a crystal-section.

II.—Geology of the Little River Group.

(1) The Geological Age of the Little River Group. (2) Revision of the Flora of the Little River Group, No. II. (3) Remarkable Forms of the Little River Group. By G. F. Matthew, D.Sc., LL.D.

On account of the discovery in this group of important and varied kinds of vegetable remains, its geological age is of much importance. This article is a brief statement of the geological evidence bearing on the age of the group. These are chiefly the relations to neighbouring formations which underlie or overlie the group, the amount of metamorphism it has undergone, and the lithological resemblance of the succession of beds to that of the Silurian strata in neighbouring districts. The conclusion is arrived at that the group is of Silurian age. There is a map showing the relations of the Little River Group to the adjoining strata.

(2) In this paper is given an account of the type of Sir J. W. Dawson's *Dadoxylon Ouangondianum*, and of two new Pteridosperms, one, *Johannophyton*, including Dawson's *Alethopteris discrepans* and his *Sporangites acuminatus* (the latter considered as fruit bracts of the former): reasons are given why these should be considered parts of one and the same plant; the fruit is shown to be a small oval seed. The other Pteridosperm is a small creeping plant with the foliage of *Aniemites*, and the fruit a small berry; it is named *Ginkgophyton Leavitti* on account of the resemblance in the form and venation of the leaves to those of the Ginkgo-tree.

This paper treats also of the Psilophyta of the formation, as well as of some new species of *Sphenophyllum* and *Whittleseya*: the Psilophyta are not thought to be typical of the genus. Six plates of fossils accompany this paper.

(3) This article treats of some animal forms and of tracts of Batrachians and Articulates of this group. A *Leaia* and a new genus of Merostome, *Belinuropsis*, are fully treated of, also the wings of two large insects are described. The footprints are partly of Batrachian and partly of 'Crustacean' type; three genera of the former are described, and three species of the latter; the Batrachian footprints are much like those of Batrachians of the Coal-measures, the others are attributed to insects or Arachnids, and are in consecutive series of tracks of various sizes.

A series of plates represent these ancient and interesting footmarks left on the sands of this old Silurian series of strata.

III.—Armenia.

In 1906 we called attention in these columns to Dr. Felix Oswald's book on the *Geology of Armenia.* This was followed the next year by his *Explanatory Notes to accompany a Geological Map of Armenia*, and we have now before us his final conclusions on the geological structure of this area, published in Petermann's *Geographischen Mitteilungen*, 1910, under the title of "Zur tektonischen Entwicklungsgeschichte des armenischen Hochlandes". The present paper is accompanied by a map showing the Tertiary fault-lines as a series distinct from those of older date; and seven panoramic views of the Musch Plain, the Malaskert Plain, Lake Van, and the Bingöl group. As indicated by its title, Dr. Oswald's new work is a purely tectonic one, and rounds off the story of the geology of a district which he has so lucidly and fully described.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

April 13, 1910.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Volcano of Matavanu in Savaii." By Tempest Anderson, M.D., D.Sc., F.G.S.

Savaii is one of the German Samoan Islands in the Central Pacific Ocean. It is entirely volcanic, is formed of different varieties of basic lavas, and is for the most part fringed with coral reefs.

The volcano of Matavanu was formed in 1905. The eruption was at first explosive, but since the first few weeks has been mainly effusive and accompanied by the discharge of an enormous volume of very fluid basic lava, which has run by a devious course of about 10 miles to the sea, formed extensive fields of both slaggy and cindery lava (*pahoehoe* and *aa*), filled up a valley to a depth in some places of probably 400 feet, and devastated some of the most fertile land in the island. The crater contains a lake, or rather river, of incandescent lava, so fluid that it beats in waves on the walls, rises in fountains of liquid basalt, and flows with the velocity of a cataract into a gulf or tunnel at one end of the crater. It then runs underground along a channel or channels in the new lava-field until it reaches the sea, into which it flows, and causes explosions attended with the discharge of showers of sand and fragments of hot lava, and the emission of vast clouds of steam.

The many resemblances to, and few differences from, the volcano of Kilauea are discussed.

2. "Notes on the Geology of the District around Llansawel (Carmarthenshire)." By Miss Helen Drew, M.A., and Miss Ida L. Slater, B.A. (Communicated by Dr. J. E. Marr, F.R.S., F.G.S.)

In this paper the authors deal with the stratigraphy and geological structure of a small area some 9 miles to the west of Llandovery, and to the north of Llandeilo. In a brief introduction the reasons for the selection of this region are mentioned, and the work of previous observers is touched upon.

The rocks consist of a varied series of sediments, including a coarse conglomerate, grits, shales, and tough blue mudstones; cleavage is almost everywhere intense.

The beds fall naturally into three divisions, as follows:—

C. Llansawel Group	C 3. Pengelli Shales (Gala fauna).
	C 2. Zone of *Monograptus communis*.
	C 1. Clyn March or *cyphus* Grits and Shales.
B. Caio Group . .	B 2. Llathige Shales and Mudstones. Zone of *Mesograptus modestus*.
	B 1. Penn-y-ddinas Grits and Shon Nicholas Conglomerate.
A. Beili Tew Group .	Beili Tew Grits and Shales.

The stratigraphical relationships are seen most clearly in the highest group (C), which is therefore dealt with first. The beds here follow each other in perfectly regular succession, with a uniform strike of E. 30° N. The basal beds, with a fauna belonging to the zone of *Monograptus cyphus*, form a well-marked ridge across country, and Upper Birkhill and Gala Beds follow to the north-west.

The second group (B) occupies a wide tract to the east of the Llansawel Group. The coarse basal deposits, and the characteristic shales and mudstones, are described from many localities.

The lowest group (A) has its greatest development on the south of Llansawel.

The structure in the eastern part of the district shows many points of interest, and is very much more complicated than in the west. The repeated outcrops of the conglomerate in the hilly region around Shon Nicholas are described in detail, and these give the clue to the structure.

The paper concludes with a general summary and a brief comparison of this district with those of Rhayader and Pont Erwyd.

II.—*April* 27, 1910.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communications were read:—

1. "On the Evolution of *Zaphrentis delanouei* in Lower Carboniferous Times." By Robert George Carruthers, F.G.S.

The small simple corals that belong to the gens of *Zaphrentis delanouei* are of common occurrence in the Lower Carboniferous rocks of Scotland. Their distribution is remarkably sporadic, but it is possible to collect over wide areas of which the stratigraphy is definitely known. A large number of specimens have been got together (some twelve hundred in all) from horizons scattered throughout the sequence. The ontogeny of these specimens has been investigated by means of serial transverse sections.

The evolutionary changes observed are confined to the disposition of the septa, which has influenced the shape of the cardinal fossula in a very marked manner. The external characters, and the spacing and curvature of both septa and tabulæ, remain unchanged.

Zaphrentis delanouei is, typically, a Tournaisian species, and it has a wide fossula, expanded inwardly. When the gens first appears in the Scottish rocks (in the Cementstone Group of Liddesdale) *Z. delanouei* is the predominant form, but is associated with a mutation (in Waagen's sense) in which the fossula is parallel-sided.

In the higher limestones of Lawston Linn another mutation appears, which, for reasons detailed in the paper, is regarded as a sport, or offshoot from the direct line of evolution.

In the succeeding Lower Limestone Group the gens undergoes further modification. Adults of the two Cementstone species are extremely rare, and the predominant form has a fossula which narrows rapidly to the inner end; in subordinate association a further mutation is also developed, in which the septa are short and amplexoid.

In the still higher horizons of the Upper Limestone Group the last-mentioned mutation becomes predominant, and persists up to the Millstone Grit, where the septa become more amplexoid.

All these mutations, in neanic life, have characters seen in adults of the preceding form; tachygenesis is so marked that earlier ancestral traits are rarely seen.

Mutational percentages are given for many localities in the Carboniferous Limestone Series of the Central Valley, together with an analysis of the data so obtained.

Brief diagnoses of the four new species are appended to the paper, together with full locality-lists.

2. "The Carboniferous Limestone South of the Craven Fault (Grassington–Hellifield District)." By Albert Wilmore, B.Sc., F.G.S.

As to the lithology of the beds, some are massive, coarsely stratified limestones, made up largely of crinoids, or corals, or shells (or mixtures of these); others are well-bedded, almost flaggy, black limestones made up of finely comminuted matter, with abundant Foraminifera. There is every gradation between these extreme types. Variation in lithological character is lateral as well as vertical.

The strata are much disturbed everywhere. A series of folds strike roughly north-east and south-west, and are somewhat complex. There is considerable repetition of beds, and thickness is not so great as at first appears. This bears on the interesting question of the comparison of beds north and south of the Craven Fault.

The well-known knolls ('reef-knolls') are discussed. Their beds and those in the immediate neighbourhood are much disturbed. Irregular coarse bedding, folding, and normal long-continued weathering will explain most of their structural and other peculiarities. A typical knoll is dissected (Swinden); and it is seen to consist of folded, faulted, grey, coarsely-bedded limestone, with numerous great joints and much evidence of internal 'weathering'. Comparison of these knolls is drawn with the corresponding hills in the dark well-bedded limestones.

It is not easy to work out the exact zonal sequence, because of the disturbed character of the strata and the prevalence of glacial and fluvio-glacial drifts. The strata are apparently all Viséan (and the author does not think that there is anything lower than Middle or Upper S).

In some beds, and under some circumstances, fossils are exceedingly plentiful and easily procured.

Some corals receive more especial notice, such as *Caninia gigantea*, Mich., which is distinctive of certain beds. Other species of *Caninia* are found. New or not well-known species of *Zaphrentis* are described. The author briefly discusses the relationships of the genera *Caninia*, *Campophyllum*, *Calophyllum*, *Zaphrentis*, and *Amplexus*. New (?) species of *Lophophyllum* are also described, and the generic characters of *Lophophyllum* are discussed. There is a remarkably localized distribution of some corals, and *Syringopora* is very common in certain of the beds.

Suggestions are made as to the advisability of the disuse of some of the specific names. It is suggested that not more than four species of Carboniferous *Syringopora* need be retained.

The Rev. Prebendary WM. HENRY EGERTON, M.A., F.G.S.,
a veteran Geologist (1811–1910).

II.—Zoological Society of London.

May 3, 1910.—Dr. A. Smith Woodward, F.R.S., Vice-President, in the Chair.

Dr. A. Smith Woodward, F.R.S., communicated a paper by Dr. R. Broom, D.Sc., C.M.Z.S., "On *Tritylodon*, and on the Relationships of the Multituberculata." The author had re-examined the type and only known specimen of *Tritylodon*, and in one or two points came to different conclusions from Owen and Seeley. The large flat piece of bone which forms the upper part of the snout, regarded by both Owen and Seeley as the frontal, was believed to be the upper part of the nasal. The supposed parietal was held to be the frontal. No distinct prefrontal could be made out; but there was believed to be a large distinct septomaxillary. The dental formula was believed to be i^3 m^7, instead of, as supposed by Owen, i^2 m^6.

Gidley's recent paper on *Ptilodus* was criticized at some length, and an endeavour made to controvert his conclusion that *Ptilodus* is allied to the Diprotodont Marsupials.

It was held that while the Multituberculates are doubtless very unlike the living degenerate Monotremes, they are more primitive than the Marsupials and not at all closely allied to them, and that till the evidence of their affinities is much greater than at present they may well be left as an independent order.

OBITUARY.

THE REV. WILLIAM HENRY EGERTON, M.A., F.G.S.

Born November 13, 1811. Died March 17, 1910.

(PLATE XXII.)

In the death of the Rev. W. H. Egerton the Geological Society has lost its oldest Fellow—one who had been elected on June 13, 1832, and had been a Fellow for nearly seventy-eight years, a record doubtless unique in the history of scientific societies. Probably the longest previous record of a Fellow of the Geological Society was that of Sir Richard John Griffith, elected a Member in 1808. He died in September, 1878, in his ninety-fifth year, after being connected with the Society for seventy years.

The fourth son of the Rev. Sir Philip Grey Egerton, ninth Baronet and Rector of Tarporley and Malpas in Cheshire, the Rev. W. H. Egerton was brother of the distinguished geologist Sir Philip de Malpas Grey Egerton (1806–81). He was educated at Brasenose College, Oxford, where he graduated in 1835, and was afterwards elected a Fellow of his College.

Inspired by the teachings of Buckland, he early gave attention to geological subjects, and in 1833 a short communication by him "On the Delta of Kander" was read before the Geological Society and published in the Proceedings (vol. ii, p. 76). The River Kander, after a course parallel to the Lake of Thun, had formerly flowed into the Aar, but owing to inundations its waters were diverted about the year 1731 into the lake. The author described the delta since formed as extending about a mile along the shore of the lake and a quarter of a mile distant from it.

In 1835 Mr. Egerton entered the Church, and was Curate at Stoke-upon-Trent 1836–9, Rector of Malpas 1840–5, Vicar of Ellesmere 1845–6, and finally Rector of Whitchurch in Shropshire for sixty-two years, having retired only two years ago. Until the end he held a Prebendal Stall in Lichfield Cathedral.

Murchison, in his *Silurian System* (1839, p. 23), acknowledges assistance from the Rev. W. H. Egerton in determining the boundary of the Lias on the borders of Cheshire and Shropshire. In 1844 Professor Edward Forbes read before the Geological Society a "Report on the Collection of Fossils from Southern India", presented by C. J. Kaye and the Rev. W. H. Egerton, who had personally obtained an extensive series of specimens from Pondicherry, Verdachellum, and Trichinopoli (Proc. Geol. Soc., iv, p. 325).

While preserving a collection of fossils and retaining interest in local geology, the Rev. W. H. Egerton had devoted his energies to clerical and educational work. "As Church dignitary, scholar, and educationist he was a Rector of whom to be proud, and Whitchurch was fortunate indeed to have had the benefit of his spiritual guidance and goodly counsel for so many decades. Between him and his parishioners there always existed a mutual esteem, and the bond grew stronger with the passing years."[1]

MISCELLANEOUS.

Sedgwick Prize Essay.—The subject for the essay for the year 1913 is "On the Unconformities in the Mesozoic Strata of the Neighbourhood of Cambridge and their Significance". The essays are to be sent in to the Registrary on or before October 1, 1912. The prize is open to all graduates of the University who shall have resided sixty days during the twelve months preceding the day on or before which the essays must be sent in.—*Morning Post*, April 1, 1910.

The Mineral Waters of Essex.—A full and interesting "History of the Mineral Waters and Medicinal Springs of Essex" has been contributed by Mr. Miller Christy and Miss May Thresh to the *Essex Naturalist* (vol. xv, pts. vii and viii, issued 1910). The subject is of more geological than medical importance, as the authors state, "Speaking generally, we may say that, with few exceptions, the reputed Essex Mineral Waters which we have analysed for the purpose of this investigation cannot be regarded as Mineral Waters at all. The few which may be rightly so classed owe such small medicinal properties as they possess almost entirely to the presence in them of magnesium sulphate (Epsom salts)."

[1] From the *Chester Courant*, March 23, 1910.

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THE

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No. VII.—JULY, 1910.

ORIGINAL ARTICLES.

I.—Erosion and Deposition by the Indus.

By Arthur Hill, C.I.E., Assistant Secretary P.W.D. Bombay.

[Communicated by the Rev. E. Hill, M.A., F.G.S., The Rectory, Cockfield, Bury St. Edmunds.]

"THE Indus has been eroding severely on the right bank, about 30 miles higher up than the erosion which I told you threatened the railway at Rohri on the left bank. The chord of the curve of the bank attacked was over $2\frac{1}{4}$ miles long, and the erosion at the apex would be as much as 100 feet a day: it amounted to 3400 feet in forty days. It has given us a good deal of trouble, as with a big breach here the water would travel 120 miles before it would be forced back to the river by the hills on the edge of the deltaic deposits, and loop embankments of great length had hastily to be constructed behind the portions of the flood-embankments threatened with erosion. We succeeded with two loops, but with the third had a breach in the weak new loop; the men have been able to keep it from spreading more than 700 feet wide, and have since got it nearly under control.

"If the bones of the famous geological mule had been on the river bank, they might have been dropped down to the 60 or 100 feet depth to which the river erodes, and have had half a mile of deposits put down alongside them, and between them and the bank of the river; for these channels in bends eroded are filled up again equally rapidly when the river cuts across the chord. So your mule might have had 60 feet depth over him, and the half-mile of new silt alongside him, in three months. The construction of a square mile of new deposits, 60 feet deep, in about two months time, is of almost annual occurrence locally on the Indus. These are, of course, not [pure ?] silt deposits; they are merely the land at the side of the river rolled over, as in ploughing.

"Pure silt deposits occur, where the river overtops its natural bank, and in side-channels of the river where the exits are getting smaller than the upstream ends. In the latter case considerable depths, 15 feet or so, of pure silt are deposited in a month or two.

"Most silt probably goes on to the sea. The average discharge of the Indus during 1906, from June to September inclusive, was 400,000 cubic feet per second. . . . The maximum quantity of silt observed in suspension was 2797 grains weight per cubic foot of water. . . . I have not worked out the quantity of silt for the year, but clay weighs about 120 lbs. a cubic foot. . . ."

The above is extracted from a private letter of my brother's, written September 15, 1909, in answer to some questions I had asked relating to the behaviour of rivers. It seems to me likely to interest others besides myself, and he has given me leave to make any use of it. I have printed it as written.

The figures work out as follows:—

The maximum quantity of silt observed in suspension gives a trifle less than 1 cubic foot of clay from 300 cubic feet of water.

The discharge of water in the four above-named months is 4,216,320 millions of cubic feet.

If this contained the observed maximum of silt it would be sufficient to deposit a layer of 1 foot of clay over 503 square miles.

II.—Some Observations on the Brighton Cliff Formation.[1]

By Edward A. Martin, F.G.S.

During the past eighteen years I have made certain observations on the cliff formation on the east of Brighton and on the sections successively brought into view by repeated falls of the cliff. The chief item to be noted from them is, that as the cliff wears back, the base-platform of chalk grows in height, that is, the old surface of the chalk dips towards the south. Also, that the layer of sand which Prestwich found above the chalk grew thinner and thinner, until it has now completely disappeared. At the same time the raised beach has grown in thickness from 1½ feet to 12 feet.

In 1890 the raised beach still remained about a foot and a half thick, as noted by Prestwich, with about 6 feet of sand beneath it. An illustration of the cliffs at this date has appeared in a little work called *Amidst Nature's Realms*, and can be referred to there. An old groyne remained, but it was in a very damaged condition, and it was noticeable that the usual accumulation of beach on the western side had not taken place there. The groyne was subsequently removed, and a low concrete wall was constructed almost as far eastward as where the wooden groyne formerly stood. When visiting the formation in 1892 I noted that there was still about 1½ feet of the raised beach, but between 3 and 4 feet of sand beneath it, the thickness between these limits constantly varying along the face of the cliff, thus showing a considerable reduction in two years.

During a visit to Brighton in September, 1895, the changes which had taken place were very noticeable, owing to the rapid undermining of the cliff formation, and the action of the weather on the porous materials of which it is composed. For many years the eastern limit of the beds had been obscured to a more or less extent, but owing to the great falls that had taken place it was possible to place a limit upon the eastern extension of the beds. This was at a point at about 300 yards east of the Abergavenny Inn. At this point there was a distinct slope upwards of the lines of bedding, these being always more or less obscure, but here sufficiently clear to mark the shore of

[1] Paper read before the Geological Society, an abstract of which appeared in the Quart. Journ. Geol. Soc., May, 1909.

chalk which bounded the small bay in which the 'Elephant Bed' of Mantell had been laid down. The raised beach here gradually ascended and formed a bank resting against the chalk, and the appearance it exhibited was so distinct that there could be no doubt that the utmost limit of the formation was shown. The lines of stratification dipping at various angles to the west were clearly apparent until reaching a point 100 yards westward, where another and larger bank of shingle had been formed, but at a lower level. West of this the strata were so indistinct as to render it almost impossible to say with exactness how the greater number of lines of stratification proceeded. Being subjected to many currents they would appear in all directions and at all dips, supposing that the weight of the overlying strata were sufficient to emphasize current-bedding. At the foot of the Rubble-drift, where the raised beach was exposed in a horizontal position, the thickness of the beach varied from 4 to 5 feet, which was a greater thickness than was to be seen when I visited the cliff in October, 1892. As the cliff had worn backward the raised beach had increased in thickness. Enormous blocks of red sandstone had recently been dislodged from the Elephant Bed, and were lying at the foot of the cliffs, whilst others of smaller size were seen to be embedded in the old sea-beach itself.

Further falls of the Rubble-cliff, and of its chalk foundation, had taken place when I paid a visit in September, 1897. Ten feet of chalk formed the lower portion of the cliff, and above this came the raised beach, as much as 8 feet thick in places, consisting of rounded stones, with very little sandy matrix. The layer of sand at the base of the beach, which in 1892 was from 3 to 4 feet thick, was now represented by a mere trace, and since that date the sand has not again appeared, as the cliff has worn back. The large rounded stones of the ancient beach rested, in fact, almost on the chalk. The Rubble-drift formation above was seen to be distinctly stratified, and as the top of the cliff was reached the flints contained in the loam became more jagged and less rounded. On the existing beach there were strewn boulders of sandstone of all sizes. One large subangular, ruddy-brown sandstone boulder, which had an exposed surface of at least 2 feet long, was seen in situ half-way up the cliff, and at the foot was a mass measuring 5 feet in its largest dimensions, others of smaller size being plentiful. Their place of origin may have been beyond the escarpment of the South Downs.

In April, 1899, the raised beach by further falls of cliff had reached a thickness of 10 feet, resting on 10 feet of chalk. The largest boulders of flint were, strangely enough, on the base of the raised beach, there was no sand, and the change downwards was an abrupt one into chalk in situ. There was no layer of green-coated flints at the junction. Passing towards the eastern boundary of the formation, the beach, instead of being continuous from top to bottom, was seen to be here split up into a top and bottom layer, each of about a foot thick: the space between them was filled with 'reconstructed' chalk, containing many boulders of chalk, these increasing in size easterly towards the limit of the formation, until the whole came to present an appearance as of chalk, almost as originally laid down.

The lower part of the Rubble-drift, which rests upon the topmost gravel, was seen to become more chalky in an easterly direction, and was made up of small semi-rounded fragments of chalk, together with large boulders of the same.

Owing to the manner in which the falls had taken place, the cliff had been cut back more in some parts than in others, with the result that the lines of stratification, which were everywhere most distinct, dipped at a high angle towards the sea on the south. Some of these lines may have been due to current-bedding: in which case it would seem to follow that much of the upper portions of the whole formation is missing, having been planed away with the upper part of the chalk at its rear. Great masses of red sandstone, grey sandstone, and here and there a mass of Tertiary iron-red breccia, strewed the foot of the cliffs. In the raised beach I extracted two rounded boulders of granite, and a few rounded laminæ of green sandstone.

In May, 1899, I noted the following observations. One large mass of red flint breccia, full of angular flints, with the interstices filled with iron sandstone, lay upon the beach at the foot of the cliff, having apparently fallen out of the Rubble-drift. It measured 7 feet long by 4 feet broad, and was 3 feet thick. The flints were not at all worn. There also lay upon the beach a mass of grey sandstone, measuring $4 \times 1 \times 1$ feet, and another of red sandstone, $4 \times 2 \times 1$ feet. Other masses of red sandstone, which in addition to the large one mentioned lay upon the beach, were all fairly rectangular in shape, but the angles were not at all sharp. The blocks appear to have been derived chiefly from the Rubble-drift, Elephant Bed, or Coombe Rock, as it has been variously called, whence came also a large slab of chalk rubble, full of rounded chalk lumps and occasional flints, which measured 2 feet long by 1 foot wide, but only averaging 3 inches in thickness.

On the raised flint beach (below the Rubble-drift) round boulders of chalk of large size occasionally occurred: in one place, in a very small area, there were thirty and more to be seen. In this there were also occasional masses, fairly rounded, of red sandstone, generally occurring near the base of the old beach. Similar blocks in the Rubble-drift are much more angular. Beneath the disused black-tarred coastguard houses, there remained now but a few feet of Rubble-drift.

A little east of the Abergavenny Inn, the stratification of the Rubble-drift is rather remarkable. A mass of reconstructed chalk appears to have found its way to the bed of the estuary, soon after the raised beach ceased to be formed, and impeded the horizontal deposit of the drift above it.

Seen again in June, 1903, the formation showed considerable changes in consequence of falls, and in the raised beach more particularly. Being the most loosely accumulated portion of the whole formation, the falls had occurred so as to leave cave-like gaps, with a platform of chalk 14 feet thick below, and a roof of comparatively loose gravel and clayey sand. The raised beach itself was 8 ft. 3 in. in thickness, and this was fairly constant throughout the whole distance of 200 yards in which the beach was visible.

In those parts where the base of the beach was clearly visible, there was a foot of larger flint stones than those contained in the main mass, and large blocks of red sandstone were visible, both at the top and at the base of the beach. About 100 yards east of the most westerly visible portion of the beach it began to enclose large subangular blocks of chalk, and became of a more and more chalky nature in an easterly direction.

It was not always easy to say definitely where the series of deposits ended in an easterly direction, and where the chalk commenced to again appear in situ. At somewhat over 200 yards to the east of where the formation is first seen, in travelling from the direction of Brighton, the gravel suddenly drops to about 6 inches in thickness, whilst upon it is chalk which has apparently been moved and redeposited. We appear here to be at the bank of the estuary down which the material was being transported, and the disturbed chalk has been deposited in the shallow water near the banks. In the same way the gravel has here been deposited very sparingly, most of it having been rolled into the central parts of the stream.

So far as the Rubble-drift is concerned the section as it now appeared was most clearly and distinctly stratified. Especially was this noticeable in that portion nearest to Brighton, where it is made up for the most part of alternate thin bands of pale reddish clay and thicker bands of chalky rubble. The pieces of chalk in the rubble are rounded in the form of pebbles, varying in size from a pea to a small plum.

About midway along the section where, in the raised beach underneath, the large blocks of chalk begin to appear, there is in the Rubble-drift, about two-thirds the way up the cliff, a remarkable band, 2 feet thick, of dark reddish clay, in which are contained large numbers of rounded chalk pebbles, the band standing out distinctly in the cliff by reason of the clay being of a darker red colour than the surrounding clay.

Large blocks of red sandstone were visible in the Rubble-drift. On the present beach I counted in a space of 50 yards square no less than forty fallen blocks, each containing on an average 8 cubic feet capacity. There were many others lying at a greater distance, but among them all I saw only three which were conglomeratic. All the others were hard red sandstone.

Standing on the rocks at low tide I could not help being struck by the appearance presented at the top of the chalk cliffs where the degradation of the chalk was going on. The line of demarcation between the chalk and the subsoil was arranged in the shape of festoons, each festoon being 2 to 3 feet across, and extending from 3 to 5 feet from the surface. Sometimes in the flinty clay resulting from the degradation a festoon had been left of white chalk untouched, whilst beneath it decomposition had proceeded. I had on a previous occasion noticed this festoon degradation in the chalk in cuttings in the neighbourhood of Birchington. It is still to be observed. A few fragments of shells (*Mya*) were found at the top of the raised beach.

A visit to the cliff in December, 1906, showed that there had been a tremendous fall since my last visit at a site not far to the east of the Abergavenny Inn. This had exposed a great rounded chalk block about 2 feet long, interstratified with the raised beach, whose thickness varied from 15 to 20 feet. The section nearest to the concrete wall on the west was as follows: chalk rising out of existing beach 10 to 17 feet, containing thick bands of flint. Above this a thickness of about 6 feet of raised beach, with some small sandstone boulders exposed therein. As the cliff recedes by denudation it will be seen that the raised beach varies in thickness, so that apparently it was laid down upon a floor that was not at one level.

On my visit in June, 1907, great masses of the cliffs appeared to be slipping away in all directions, ready to fall at subsequent recurrences of wet or frosty weather.

In visiting the section again in September, 1908, I found that the chalk base had been cut into considerably by the sea, so that three or four little bays had been formed. That nearest to the concreted embankment was about 100 yards across. Here the section was as follows: the lowest 12 feet of chalk had been faced by concrete, above which 5 feet of chalk was exposed. Next above came 12 feet of pebbles, the largest stones being at the base, and the topmost being much mixed with sand. Then came 10 feet of stratified rubble, the remainder to the top of the cliff being, as a rule, but obscurely stratified. Beyond the baylet in which this section occurred the formation was well exposed for about 100 yards beyond the abandoned inn at the top of the cliff, and close to the site of the great fall of two years before. Nearly all of the material which then fell had, however, disappeared; there was a little of it remaining, reaching to about 17 feet up the cliff. There was still exhibited about 250 yards of the formation as a whole, reckoning east and west along the face of the cliff.

It will not fail to be observed that in spite of the large amount of rubble which is constantly falling but little accumulates as a talus at the foot of the cliffs. The floor will be seen to consist almost entirely of chalk. It will occur to students of coast-erosion that this material will have to be prevented from being carried away if the cliffs are to be preserved. Even the lowest tide shows no trace of the material, and there must therefore be undercurrents which carry away the debris into deep water. Only the sandstone and chalk boulders remain for any considerable length of time.

III.—Sedgwick Museum Notes.

New Fossils from the Dufton Shales.

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

(PLATES XXIII AND XXIV.)

(*Concluded from the May Number, p.* 220.)

Part III.

BRYOZOA.

Crisinella Wimani, sp. nov. Pl. XXIII, Figs. 1–3.

Zoarium composed of a group of branches of equal size diverging in a fan-shaped manner in nearly the same plane from a single short somewhat stouter stem; the branches originate and increase by repeated bifurcation, which takes place at uneven intervals proximally, and most frequently near the stem where the branches also are less regularly disposed and somewhat flexuous; but further from the base the bifurcation is rare and more regular, and the distal portions of the branches are nearly straight and sub-parallel or only very slightly divergent. Zoœcial openings present only on one side; zoœcia arranged in 3–4 longitudinal rows, the outer row on each side composed of regularly disposed equidistant zoœcia of equal size and placed alternately; peristomes prominent, laterally projecting outwards as short sharply triangular spines directed forwards and situated about one to one-and-a-half times the diameter of the branches apart; zoœcia in the one or two inner longitudinal rows without prominent peristomes, opening obliquely on the face of the branches, smaller than the lateral rows, and somewhat irregularly arranged. Reverse face of branches non-celluliferous, minutely pitted.

		mm.
Dimensions.	Length of zoarium . .	about 20·00
	Width of zoarium . .	about 25·00
	Width of branches . .	about 0·75

Remarks.—We may compare this species with *Cr. œilensis*, Wiman,[1] from the Borkholm Beds, but the zoœcia of the lateral rows in the latter do not project so much, and the reverse face is stated to be smooth.

BRACHIOPODA.

Orthis duftonensis, sp. nov. Pl. XXIV, Figs. 5–11.

Shell sub-quadrate to transversely semi-elliptical, usually rather wider than long and widest across middle; biconvex to flattened; valves shallow. Hinge-line straight, slightly less than maximum width of shell; cardinal angles sub-rectangular to obtuse. Pedicle-valve sub-conical, weakly convex; hinge-area large, triangular, not steeply inclined, but making an angle of 60°–75° with general surface of valve, striated parallel to hinge-line, and crossed by rather narrow triangular delthyrium; beak not incurved. Brachial valve very slightly convex, not so deep or conical as pedicle-valve, more or less flattened; faint median longitudinal depression occasionally present; hinge-area narrow, triangular, about one-third the width of that of opposite valve and steeply inclined to it, but only making an angle of about 20° with general surface of its own valve; delthyrium narrow triangular; beak inconspicuous, small, not incurved. Surface of valves regularly ornamented with 40–45 simple straight narrow rounded equidistant prominent radiating ribs, continuous from beak to margin, of equal strength, separated by equal rounded concave interspaces one-and-a-half times to twice the width of the ribs; interspaces marked by numerous regularly and closely set concentric lines or lamellæ becoming weaker or obsolete in passing over ribs. A few shorter ribs, not more than 6–8 on a valve, are generally intercalated, arising at one-third to one-half the length of the shell, and

[1] Wiman, Bull. Geol. Inst. Upsala, 1900, No. 10, vol. v, pt. ii, p. 181, pl. vi, figs. 12–16.

rapidly attaining the size of the primary ribs; and being set at the same distance apart they are indistinguishable at the margin from the primaries.

Interior of pedicle-valve with short triangular hinge-teeth and small sub-ovate muscle-scar, about one-fourth the length of the valve, rather deeply sunk and circumscribed by a ridge, weakly bilobed in front and composed of two small diductors separated by very narrow linear adductors. Pair of median vascular sinuses, contiguous and parallel at first, run forwards from muscle-scar, ultimately diverging and curving outwards laterally.

Interior of brachial valve with narrow straight linear cardinal process borne on rather massive thick hinge-plate, continued anteriorly as broad low rounded ridge between deeply sunk but indistinctly defined posterior adductors; anterior adductors not visible; dental sockets deep, with strong walls and stout prominent triangular crura.

Average Dimensions.—Length 30 mm.; width 25 mm. The smaller (younger) examples are usually somewhat broader.

Remarks.—In shape this shell much resembles some examples of *O. calligramma*, Dalm., but the species *O. plicata*, Sow.,[1] which Davidson regarded as merely a variety of it, is closely similar, especially in internal characters, but the cardinal angles are not really pointed or mucronate in *O. duftonensis* (though internal casts often give an erroneous impression), nor are the ribs angular, nor the interspaces of less width than the ribs. The typical *O. calligramma* is more convex, the beak of the pedicle-valve more incurved, and the ribs fewer, but its general shape and internal characters are very similar, and it agrees also in the simplicity of the ribs and ornamentation. The form ascribed to this species by Wiman,[2] from the Asaphus Limestone of the Baltic province, appears to bear a considerable resemblance to our species.

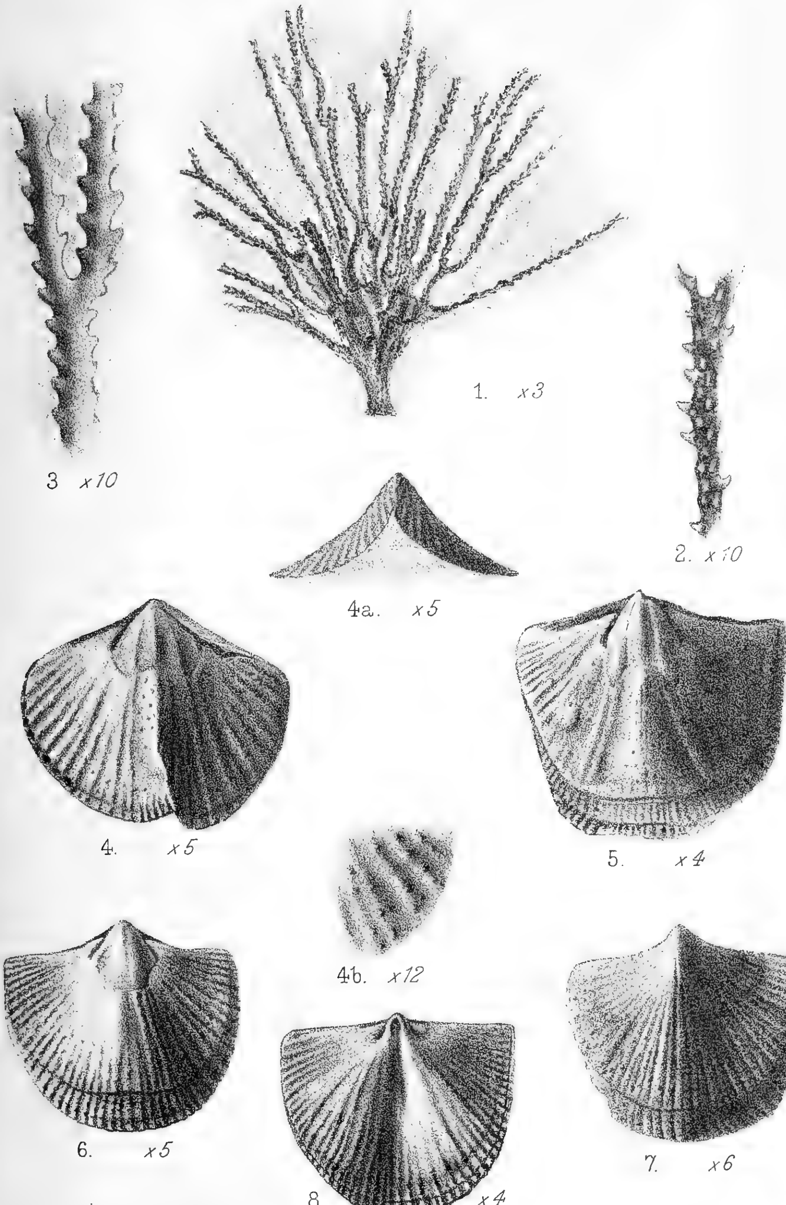
So much confusion and indefiniteness has been caused by putting well-marked varieties (or species) occurring on different stratigraphical horizons into *O. calligramma*, that it seems desirable to separate specifically this very strongly characterized local form under the name *duftonensis*.

Orthis melmerbiensis, sp. nov. Pl. XXIII, Figs. 4–8.

Shell sub-quadrate, strongly folded along median line with dependent lateral lobes; anterior margin angulated strongly in middle; hinge-line straight, equal to or slightly greater than width of shell; not auriculate. Pedicle-valve swollen, convex, angulated longitudinally down middle, sub-carinate, with lateral portions hanging down and flattened; beak small, elevated, prominent, rising above hinge-line, slightly incurved; hinge-area triangular, rather large, vertical or steeply inclined. Brachial valve divided into two lobes by strong deep median sulcus, rapidly increasing in depth and width towards front margin, which is angulated; beak small, with narrow hinge-area. Exterior of shell ornamented with about 30 fine, closely set

[1] Davidson, *Brit. Foss. Brach.*, vol. iii, p. 245, pl. xxxv, figs. 25, 26; pl. xxxvii, fig. 1.

[2] Wiman, Bull. Geol. Inst. Upsala, 1907, vol. viii, p. 103, pl. vii, figs. 28–30.



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

New Fossils from the Dufton Shales.

subangular ribs, nearly straight, equidistant on margin and of equal size, mostly dividing at one-fourth to two-thirds their length and each bearing a single row of rather distant short tubular erect spines, specially developed on the lateral portions of the valves; a fine close concentric lineation is also present. Interior of pedicle-valve with short impressed sub-triangular muscular scar widening anteriorly and broadly excavated in front, about one-third the length and width of the valve and composed of a pair of divergent diductors enclosing elongated oval adductors; occasionally two straight narrow divergent vascular ridges are traceable running forwards from the anterior outer angles of the muscular scar to a concentric sub-marginal ridge (often present). Interior of brachial valve with small rounded knob-like cardinal process; no thickened hinge-plate; crura short, sub-triangular; low narrow median ridge running forwards for about one-half the length of valve from cardinal process; muscle-scars indistinct.

		mm.
Dimensions.	Length . .	7·5
	Width . .	9·0

Remarks.—This shell somewhat resembles *O. vespertilio*,[1] Sow.; but the ornamentation is different and the internal characters are not quite identical, the cardinal process is not raised on a hinge-plate nor the adductor muscles deeply sunk, while in the pedicle-valve the muscle-scar is not saucer-shaped, but triangular and sub-bilobate; the submarginal ridge and hollow spines also are special features. It might be thought that this shell is merely a variety of the protean *O. testudinaria*, Dalm., using this specific name in the loose and comprehensive manner customary. But it seems undesirable to stretch this species yet more; and indeed the internal characters and surface-spines are quite sufficient to separate the Dufton form.

Orthis (Scenidium?) equivocalis, sp. nov. Pl. XXIV, Figs. 1–4.

Shell transversely sub-fusiform, widest along hinge-line, with acutely angular cardinal extremities. Pedicle-valve strongly convex, most so in middle portion, cardinal angles somewhat flattened; beak high, incurved, with triangular, steeply inclined hinge-area; muscular area about one-third length of valve, sub-quadrate, not deeply impressed, divided into two pairs of sub-parallel scars, the outer ones being the diductors; teeth short, strong; small apical foramen apparently present. Surface of pedicle-valve furnished with pair of equal median ribs, smaller than the rest, and rather more closely placed, with 7–8 stronger subangular ribs on each side, very slightly curved and somewhat decreasing in strength towards lateral angles. Brachial valve moderately convex, but much less so than opposite valve; bilobed, with shallow median sinus widening anteriorly to over one-third the width of the valve; small, inconspicuous beak, and narrow hinge-area; narrow linear septum present, about one-fourth the length of the valve, with sub-parallel crural plates of same length on each side; muscular impressions indistinct. Surface of brachial valve with single straight median rib rather smaller than the rest, flanked

[1] Davidson, *Brit. Foss. Brach.*, vol. iii, p. 236, pl. xxx, figs. 11–21.

by 8–9 simple subangular straight ribs on each side, decreasing in strength towards lateral angles, and equal to or rather narrower than the subangular interspaces, which occasionally show a fine central line down them. In a few cases a small secondary rib arises close to the margin on the flank of a primary rib on either valve, but it is always short and inconspicuous. Surface of valves covered with coarse punctæ (showing as sharp pustules on an impression of the outer surface) arranged with some regularity in concentric and radial rows.

Dimensions.		mm.
	Length . .	5·5
	Width . .	8·0

Remarks.—This little shell is much like some species of *Scenidium*, the character of the ribbing and punctation, as well as the shape of the shell, recalling members of this genus. We may especially compare *Sc. œlandicum*, Wiman,[1] from the West Baltic Leptæna Limestone. The non-formation of a spondylium in the brachial valve is, however, an important difference, but Hall & Clarke[2] have pointed out that there are transitional forms between *Orthis* and *Scenidium*, and probably this species is such. It cannot be regarded as the young or a variety of *O. actoniæ*, Sow., the details of the ribbing and punctation, as well as the internal characters, being distinctive.

Postscript. Since the May number of the Geological Magazine was issued Dr. Marr has pointed out to me that there is some doubt as to whether the beds from which the above-described fossils were obtained are strictly referable to the Dufton Shales in the recent and restricted use of the term. Lithologically the rock resembles the Corona Beds and contains *Lingula tenuigranulata.* However, Professors Harkness and Nicholson employed the name Dufton Shales in a wide sense, including in them the Corona and other beds, and it is with this earlier and broader application that the term must be here understood. It is unfortunate when the same term has thus been used with two different meanings, particularly as it results from an alteration of its original significance.

EXPLANATION OF PLATES XXIII AND XXIV.

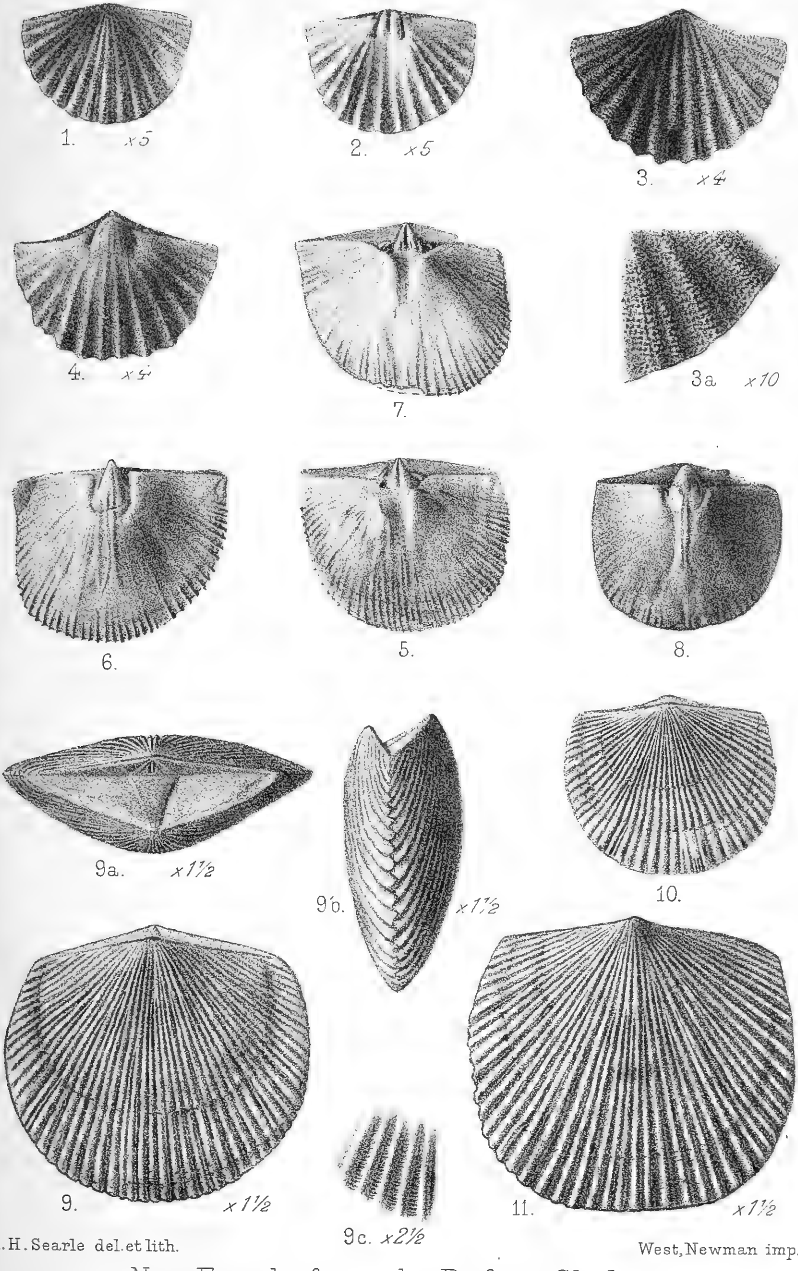
Plate XXIII.

Fig.
1. *Crisinella Wimani*, sp. nov. Zoarium. × 3.
2. Ditto. Celluliferous side of branch. × 10.
3. Ditto. Reverse side of branch. × 10.
4. *Orthis melmerbiensis*, sp. nov. Internal cast of pedicle-valve. × 5.
4*a*. Ditto. Anterior marginal view of same specimen. × 5.
4*b*. Ditto. Portion of surface of same valve. × 12.
5. Ditto. Internal cast of pedicle-valve. × 4.
6. Ditto. Ditto. × 5.
7. Ditto. Wax squeeze of pedicle-valve, showing ribbing. × 6.
8. Ditto. Internal cast of brachial valve. × 4.

Plate XXIV.

1. *Orthis* (*Scenidium?*) *equivocalis*, sp. nov. Impression of brachial valve. × 5.
2. Ditto. Internal cast of same brachial valve. × 5.
3. Ditto. Impression of pedicle-valve. × 4.

[1] Wiman, *Arkiv f. Zool.* (Stockholm), 1907, Bd. iii, No. 24, p. 7, t. i, figs. 5–11.
[2] Hall & Clarke, *Palæont. N.Y.*, vol. viii, Brach. i, p. 241.



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

New Fossils from the Dufton Shales.

FIG.
3*a*. *Orthis* (*Scenidium*?) *equivocalis*, sp. nov. Portion of surface of same valve. × 10.
4. Ditto. Internal cast of same pedicle-valve. × 4.
5. *Orthis duftonensis*, sp. nov. Internal cast of brachial valve. Nat. size.
6. Ditto. Internal cast of pedicle-valve. Nat. size.
7. Ditto. Internal cast of brachial valve. Nat. size.
8. Ditto. Internal cast of pedicle-valve. Nat. size.
9. Ditto. Brachial valve of complete specimen. × $1\frac{1}{2}$.
9*a*. Ditto. Posterior view of same specimen. × $1\frac{1}{2}$.
9*b*. Ditto. Lateral view of ditto. × $1\frac{1}{2}$.
9*c*. Ditto. Portion of surface of ditto. × $2\frac{1}{2}$.
10. Ditto. Brachial valve of another complete specimen. Nat. size.
11. Ditto. Pedicle-valve of another complete specimen. × $1\frac{1}{2}$.

IV.—On the occurrence of Wind-worn Pebbles in High-level Gravels in Worcestershire.

By Leonard J. Wills, M.A., F.G.S., Fellow of King's College, Cambridge.

(PLATE XXV.)

WIND-WORN pebbles are somewhat rare in England, and accordingly it may be of interest to record the occurrence of a deposit of which they form a prominent feature. This has been met with in several quarry-sections at Hill Top, near Bromsgrove in Worcestershire, at about 350 feet above sea-level. I am indebted to Mr. Willcox, the owner of one of the quarries, for pointing out these pebbles to me.

The quarries are opened in the Lower Keuper Sandstone, and the deposit under consideration occurs on the ridge of the hill in channel-like depressions cut out of the underlying sandstone. To the north-west there are patches of gravel capping the hill, but so far I have not detected wind-polished pebbles in them, and I am rather inclined to regard the two deposits as distinct.[1]

As exposed in the quarries, the deposit is a loose red-brown sand, with occasional streaks of tough clay, and may attain a thickness of about 10 feet. In places the sands are blackened by an infiltration of an oxide of manganese. In cases where pebbles lie in clay, sand-grains may be cemented to them by this oxide. The sand is largely composed of fairly fine quartz-grains, usually angular, and rarely rounded, but there is also a great quantity of very much smaller and quite angular material, and a few large flakes of white mica.

The wind-worn pebbles lie in a somewhat discontinuous layer towards the base of the deposit and occasionally higher up in it. They are, as I hope to show, more or less highly polished, according to the nature of the material of which they are composed, but nearly all show a dimpling which has resulted from the selective action of the wind. These little depressions are polished like the rest of the stone. But possibly the most striking feature that nearly all of the pebbles show is the presence of sharp angular ridges, which give

[1] One large quartzite pebble, having a very typically wind-cut appearance, has been found about $1\frac{1}{2}$ miles to the north-east of Bromsgrove, while other pebbles with a considerable polish may be seen in the fields near Apesdale. So it is possible that similar deposits to those at Bromsgrove may eventually be discovered in that neighbourhood also.

them a more or less facetted appearance. I have not been able to convince myself that any large face has actually been produced by the wind, but natural fractures and pre-existing faces have been ground down, and the sharp intervening ridges have been preserved and accentuated. This could not possibly have come about under water.

It may be of interest to examine the manner in which the same erosive action has affected different kinds of rocks. The pebbles found are capable of derivation either from the Bunter Pebble Beds or from glacial deposits.

1. Pebbles probably derived from the Bunter.

(1) *A mottled green and purple grit* (Pl. XXV, Fig. 1).—On the side shown in the figure a typical dimpled surface with a greasy lustre is seen, while the other side preserves the water-worn contours that it possessed in Bunter times. The sharp edge seen round the outside is to be noticed, since it gives evidence of actual cutting power in the sand-blast.

(2) *A small pebble of black felstone with veins of quartz* (Pl. XXV, Fig. 2).—This is polished all over. The sharp line up the centre, shown in the photograph, possibly indicates an edge modified by wind-action, as a result of the grinding down and remodelling of a natural fracture. In this way a rude dreikanter form is obtained. It is possible, though I do not think it probable, that the shaping is entirely due to wind-action. The selective action of the sand-blast is seen in the way the quartz veins stand out.

(3) *Coarser grits.*—These are chiefly noticeable in regard to the projection of the quartz-grains and to polishing of the depressions between.

2. Pebbles probably derived from Glacial Deposits.

(1) *North Welsh Andesitic Ashes.*—Boulders of this kind are common and may attain a large size (up to 13 or 14 inches through). They vary slightly in composition, but they nevertheless show much the same external phenomena. They are not so highly polished as are the quartzite and quartz pebbles derived from the Bunter, but are characterized by an irregular pitting and grooving. The latter is really more comparable to the elongation of the pits in a common direction than to actual grooving. In a very coarse ash with large quartz-grains these stand out and are well polished.

(2) *Felspathic Grits* (probably Carboniferous).—Two specimens of very similar grits have been found. One is about 9 inches long and shows the effect of the wind-erosion on the rock as a whole, whereas the other is quite small and, though equally angular, is instructive as illustrating the selective action of the wind on heterogeneous material. The sides of the larger stone have the softer parts worn away in more or less parallel strips. Its lower surface is irregularly flaked and barely polished at all.

(3) *Silicified Crinoidal Limestone* (Pl. XXV, Fig. 3).—These pebbles take a very high polish and look as if they had been rubbed with oil. There are occasionally deep round pits in them which are not so well

polished. These represent the hollow casts of crinoid stems. It may be noted that these silicified limestones are always more or less angular, but this does not preclude the possibility that they have been derived from the Bunter.

(4) *Gannister* (Pl. XXV, Fig. 5).—A very fine specimen of a gannister pebble is here figured. It was found by Mr. Willcox, who sent it to me. On the reverse side it is smooth but not intensely polished, whereas on the side figured a very high glaze is seen. More remarkable still is the sharp angular ridge which surrounds the top of the stone. The upper surface has an appearance as if the rock possessed a slight conchoidal fracture along which pieces had flaked off under the influence of frost. The hollows left have been highly polished, and the ridges between are quite sharply defined and angular. At (*a*) we can see how the erosive agent has picked out a natural joint in the rock and enlarged it.

This fine specimen gives strong evidence in favour of the conclusion that these cases of polishing are due to the action of wind-erosion, for it is evident that the wind is the only agent capable of polishing concave surfaces and, at the same time, of leaving the ridges between the depressions sharp.

In most of the cases considered above where a dreikanter form has been observed, it is due to accidental fracture. But there are instances where one is tempted to say that the general shape is the direct result of cutting by a sand-blast, the pebble having a roughly tabular form with a flattish upper surface surrounded by a sharp ridge. Such shapes are common among desert pebbles from Wadi-Halfa in Egypt, and may there represent the first stage in the production of a dreikanter. A specimen of this type preserved in the Sedgwick Museum, Cambridge, is here illustrated on Pl. XXV, Fig. 4, and may be compared with Pl. XXV, Fig. 5.

It is striking that the sand in which the stones lie is composed of angular material. But it is at the same time to be remembered that wind-rounded sand-grains are almost always of larger size than those found here.

The presence of Welsh erratics among these polished pebbles fixes the age of the deposit as either Glacial or post-Glacial. This is of interest since, throughout North Germany, wind-cut pebbles are found lying on the Boulder-clay at the base of the Loess. In England too one wind-cut pebble has already been recorded which was probably derived from glacial deposits.[1]

The remaining records of wind-polished stones in England (other than recent) show that probably their production was a rather local phenomenon and not likely to be very widely observed. Further, they are not confined to beds of one age. Mr. Clement Reid, to whom my thanks are due for help in dealing with this question, mentions some from Dewlish, where they appear to be late Pliocene or of the age of the Cromer Forest Series.[2]

Prestwich[3] found similar pebbles at Portland. They were there

[1] F. A. Bather, Proc. Geol. Assoc., 1900, vol. xvi, p. 396.
[2] C. Reid, "Pliocene Deposits of Britain": Mem. Geol. Surv., 1890, p. 206.
[3] J. Prestwich, Quart. Journ. Geol. Soc., 1875, vol. xxxi, p. 29.

associated with *Elephas antiquus*, *E. primigenius*, and *Equus fossilis*, etc. Their age is probably post-Glacial.

A second record by Mr. Clement Reid is of especial interest to us. He found Palæolithic gravels with polished pebbles at Savernake Forest, and his comments on the climate of those times are pertinent. He argues that it must have been milder than on the Continent, where steppe conditions were prevailing, and yet that "we have indications of drought in some of the mollusca and small mammals—perhaps also in the extreme poverty of the flora".[1] Yet the palæontological evidence in favour of steppe conditions is still meagre. *Lagomys pusillus* and *Spermophilus* are known from the Ightham Fissures, while the Saiga antelope is recorded from the Thames Valley. These, in that they are quite typical steppe animals, should form good evidence of the prevalent climate.

I think, therefore, that we are justified in putting this occurrence of wind-worn pebbles on record, as another possible link in the chain of evidence in favour of dry conditions verging on those of the present-day steppes having occurred locally in Great Britain in post-Glacial times. The abundance of fluviatile deposits belonging to this period precludes the possibility of true steppes having existed over wide areas in our country. But at the same time, though the melting and retreating ice-sheet provided great quantities of water, yet the climate may have been fairly dry, especially if, as Mr. Harmer has suggested, the prevalent winds blew at that time from the east. It must, however, be confessed that the general prevalence of steppe conditions in this country is still very far from proven.

EXPLANATION OF PLATE XXV.

Fig. 1. Wind-worn pebbles of fine-grained felspathic grit. $\frac{2}{3}$.
,, 2. ,, pebbles of black felstone. $\frac{2}{3}$.
,, 3. ,, pebbles of silicified limestone. $\frac{2}{3}$.
,, 4. ,, pebble from Wadi-Halfa, Egypt. $\frac{2}{3}$.
,, 5. ,, pebble of Gannister. $\frac{1}{2}$.

Figs. 1–4 photographed by author; Fig. 5 by W. Tams.

V.—The Upper Keuper Sandstones of East Nottinghamshire.[2]

By Bernard Smith, M.A., F.G.S.

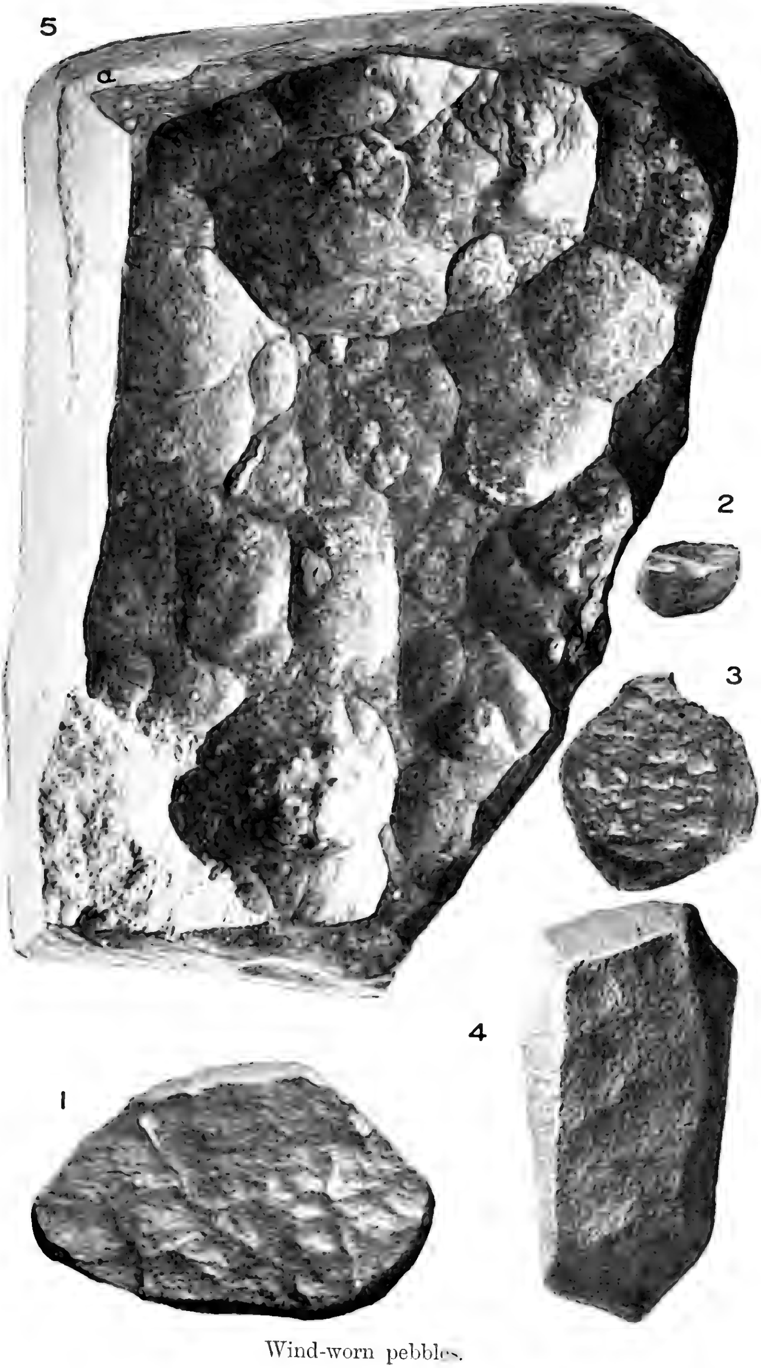
(PLATE XXVI.)

THE Keuper rocks of East Nottinghamshire occupy almost the whole of that part of the county, striking slightly E. of N. and W. of S., and dipping at a very low angle in an easterly direction.

They have been described by many competent local observers such as the Rev. A. Irving, Messrs. J. Shipman, E. Wilson, J. F. Blake, W. J. Harrison, and A. T. Metcalfe; and also by W. H. Dalton and W. T. Aveline in several publications of the Geological Survey between 1879 and 1888. During the recent survey the succession

[1] C. Reid, *Summ. Prog. Geol. Surv. Gt. Brit.* for 1902, p. 207. See also the same author in *Nat. Sci.*, 1893, vol. iii, p. 367.

[2] With the permission of the Director of the Geological Survey.



Wind-worn pebbles.

has been mapped and described once more,[1] but in no case has particular attention been paid to the composition and structure of the sandstones of the Keuper Marls, which are usually dismissed by writers in as few sentences as possible. The following notes collected between 1906 and 1910 may therefore serve a useful purpose in supplementing previous descriptions of the Marls, and may throw light upon the probable method of accumulation of this somewhat monotonous formation.

Surface Features.—The sandstones of the Keuper Marl of Nottinghamshire are locally known as 'skerries', and the relief and characteristic appearance of the outcrop is directly due to these 'skerries' with their associated beds—a combination which I shall refer to as 'skerry-belts'. In the almost complete absence of drift the marls have weathered in such a way that practically every feature is the expression of some resistant bed which may be quite invisible at the surface. In rare cases this may be a hard blocky marl, but usually it is a skerry-belt.

If the Keuper Marl plateau, where least dissected, is followed in the direction of the dip, the successive skerry-belts encountered—unless individual skerries are very thick and hard—do not make much show, but come on gradually, first the lower layers and then the higher ones. When, however, the plateau is well dissected, the beds forming the belt stand out boldly, especially where the strike-streams trench the upland close to the now well-developed escarpments.

In the north-eastern part of the county the lower skerries form an upland gently sloping in an easterly or south-easterly direction drained by dip-streams flowing to the Trent. Standing upon one of the divides between the valleys and looking north or south, ridge after ridge, supporting village after village, may be seen at the same level. From this level the slopes drop in steps over successive skerry-belts to the valley bottoms, the edge of each remnant of the upland being the edge of the valley upon that side; hence the characteristic scenic effect is the straight sky-line, whether in long ridges or isolated hills.

Skerry-belts.—The skerry-belts—usually about 6 feet thick—are composed of alternations of micaceous sandstone, shale, and marl with occasional veins of fibrous gypsum, and are unexpectedly persistent, although individual beds of stone may occasionally thin out whilst others become thicker.

The sandstones vary from an exceptional thickness of 3 feet to less than half an inch, the thicker beds being often split up by sandy shales. In the belts it is common to find (in upward succession) red marls and clays followed by a thin layer (1–2 inches) of green and blue clay, which is succeeded abruptly but conformably by a sandstone. Above the latter there is a gradual passage through green to green-red and finally red clays and shales. Pseudomorphs after salt crystals, formed at the surface of the green-blue clay, are frequently found on the bottom surface of the sandstone. The sandstones are pale in

[1] "The Geology of the County between Newark and Nottingham": Mem. Geol. Surv., 1908, pp. 35–54, and in *Summaries of Progress* for 1907–8.

colour (white, cream, grey-green, or pale-blue), but if thin may be stained pink externally. The shales often have the 'watered' appearance characteristic of the Waterstones,[1] and were evidently formed under the same conditions. Chocolate or bright-red marl frequently passes abruptly into bright-green marl in both a vertical and horizontal direction. Small galls of red marl up to half an inch in length frequently occur in the green shales and green ones in the red shales, and it is noticeable that the green shales are often of a coarser texture than the red.

The Skerries.—Mr. W. H. Dalton[2] describes the majority of the sandstones in the Keuper Marl as "very fine-grained, compact, grey or even pure white, and very hard; in the latter case containing a high percentage of carbonate of lime . . . It is too soft for traffic, but hardens considerably by exposure, which permits of the deposition of crystalline carbonate of lime previously in solution in the pores of the stone. The cementing material appears to be wholly carbonate of lime, the rock falling into sand by submersion in hydrochloric acid". He further adds that there are "thin bands of sandstone, sometimes rather coarse, soft, and of the same deep colour as the marls". These last-mentioned sandstones are thin and so scarce that they are almost unnoticeable, and pink in colour rather than deep red, like the marls. On hammering they generally expose a pale core, which suggests that the reddish tint is due to weathering.

The skerries fall into three types in ascending order—

1. Pale sandstones with carbonates.
2. Pale flaggy sandstones with more silica.
3. Coarse sandstones with larger rounded grains, mostly siliceous.

1. These form the main stone horizon near the base of the division, and give rise to the most characteristic plateau features. They frequently exhibit drift-bedding and ripple-marking, or show a peculiar contorted arrangement of the laminæ (suggestive at first sight of concretionary action). Here and there lumps of softer laminated stone lie rolled up and embedded in non-laminated portions and tend to weather out, giving the stone a honeycombed appearance.

Two slices were examined microscopically, and in both cases the rock contained quartz and carbonates in about equal proportions. The first was a compact typical building stone (Maplebeck, Notts), slightly banded. It consists of small angular quartz-grains of very similar size and derived rhombs of dolomite. The dolomite never occurs as plates enclosing the quartz-grains, but as rhombs of various sizes, *with rounded angles and broken faces.* A little calcite may be present, but is not very much in evidence. The quartz-grains—generally less than $\frac{1}{10}$ mm. in diameter—are derived from plutonic rocks and are full of fluid cavities. The banded appearance is due to the scarcity of quartz, which drops from 50 to 10 per cent. along certain lines, and must therefore be due to sedimentation.

The second example was a softer-looking ripple-marked rock,

[1] The term originally used by Mr. G. W. Ormerod, because the surfaces of some of the beds had a watery appearance, like watered silk.

[2] "The Geology of the Country around Lincoln": Mem. Geol. Surv., 1888, p. 8.

similar to the last, but in which the quartz-grains are of more uneven size. The laminæ of the ripple-marks are in this case due to either dolomite or quartz rising to 90 per cent., as compared with 10 per cent. of the other constituent. Part of the rock is patchy, i.e. contains nests of quartz or dolomite in the above proportions. The quartz shows strain shadows, and the larger grains ($\frac{1}{10}$ mm.) contain fluid cavities with gas bubbles. The dolomite granules, much smaller than the quartz-grains, are often stained with limonite. There are a few accessory minerals of no great importance, such as magnetite, zircon, sphene, and a pale pleochroic greenish-brown mica.

2. The second series commences at from 360 to 370 feet above the base of the Keuper Marls, and consists of thinner and less persistent sandstones than those of the lower series. They have a siliceous, often banded, appearance, and weather out as rough, slaggy-looking pieces of stone, with a brown or blue-black stain due to iron or manganese compounds, strikingly different from the paler and cleaner fragments of the lower skerries.

A slice of a wavy-banded specimen shows that the light bands (reflected light) consist of quartz with small brightly polarizing dolomite granules or rhombs, which make up perhaps 30 per cent. of the rock. The remaining 70 per cent. is mostly quartz with a little accessory twinned felspar (microcline and anorthoclase). The angular quartz-grains (all about $\frac{1}{10}$ mm. in size) show strain shadows, and occasionally pack as a mosaic with little or no dolomite between them. Some appear to be cemented together or to be parts of a previous quartzite. A little detrital calcite mud may be present, and angular cavities in the slice may represent plates of that mineral.

3. In hand-specimens the third type consists of flaggy and false-bedded sandstones, in colour white to bright-red, resembling millet-seed sandstones with rather loosely cemented grains. These rocks are found some 120 feet below the base of the Rhætic beds, or about 580 feet above the base of the Keuper Marls.

Under the microscope the grains are seen to be of two sizes. The larger are often beautifully rounded, and average $\frac{1}{2}$ mm. in size; the smaller are of similar composition, but more angular, occupying the interstices between the first. The majority consist of quartz (percentage over 95), with strain shadows and fluid cavities with bubbles, and there has sometimes been a secondary growth of silica upon the surfaces of the grains. Felspar with fine lamellar twinning (? oligoclase), fine quartzites, and quartz-schists are also present. An interesting point is the appearance of several grains composed of dolomite and quartz, having the appearance of rolled fragments of a rock resembling that last described.

Ripple-marks and Contorted Structures. — These structures are commonly found in the lower sandstones, but are not confined to them. There seems to be no doubt that the drift-bedding and ripple-drift was the result of water-action, one set of ripples being sometimes partially destroyed and another laid down in a slightly different position (Fig. 1). Occasionally the same slab shows ripples crossing a second set at right angles.

In the first two skerry types the quartz fragments and dolomite fragments are very even grained, their different percentages in the laminæ being doubtless due to oscillations in the amount of supply during sedimentation. The smaller size of the dolomite grains, as compared with the quartz, may be explained by the higher specific gravity of the dolomite.

The contorted structure shown in Pl. XXVI, Fig. 1 is not so easily explained. If the upper part of such a slab is stripped off—as it often is by weathering—an irregular lumpy surface, consisting of smooth curves and folds, would be exposed. This appearance, taken in conjunction with the occurrence of dolomite, is suggestive of concretionary action; I would, however, attribute it mainly to disturbance of the ripples while the deposit was still in a soft and pasty condition. In a few cases, however, there is a suggestion that in addition to ripple-marks the layers of sediment were arranged in rounded curves (somewhat like those in some parts of the Cotham Marble), but afterwards disturbed by current-action. Freshets of water, producing swirling currents,

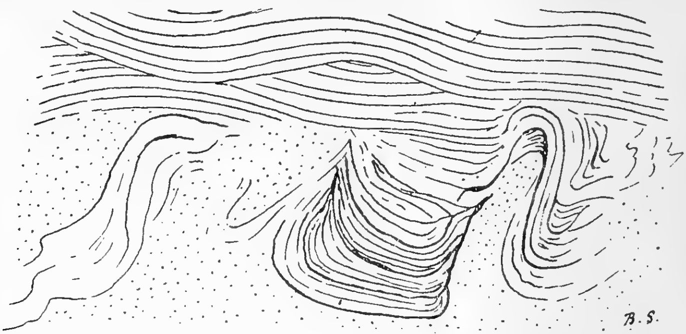


FIG. 1. Stone in wall of Sutton Church, Notts, with contorted laminæ. Nat size.

would sweep along with them a heavy burden of sand, *and tear up* (Fig. 1) *or contort* underlying ripple-marked layers, embedding them in a structureless deposit. When the flood-waters began to come to rest a layer of ripple-marked sediment passing upwards into drift-bedding (Fig. 2) would be deposited upon the top of the broken[1] and contorted layer.

An actual case of the formation of such structures is quoted by Mr. A. W. Rogers, of the Cape Geological Survey, with whose permission the accompanying photograph (Pl. XXVI, Fig. 2) is reproduced. "At the mouth of the Prieska ravine a certain bed of alluvium on the left bank has its laminæ contorted. They often stand vertically, and are even curved into the shape of an inverted bulb. Above and below this layer the laminæ are false-bedded or lie flat."[2] He attributes

[1] Sorby (Quart. Journ. Geol. Soc., 1908, vol. lxiv, p. 197, pl. xiv) has shown how the sandy ashes of the Langdale slates were deposited sometimes as ripple-drift, which became torn up and contorted as the velocity of the sediment-bearing current increased. Sorby's experiments seem to show that a current of about 2 inches per second in shallow water would suffice to form ripples in sediment as fine as that of these skerries. A velocity of 6 inches per second would wash up and destroy them.

[2] Cape of Good Hope, *Thirteenth Annual Report of Geol. Commission* for 1908, p. 107.

the contortions to swirling waters which he saw above the spot and whose action is clearly traced in the Koegas ravine, where for some 800 yards above the mouth laminated strongly false-bedded alluvium is common, on the left bank dipping up the ravine, on the right bank down the ravine.

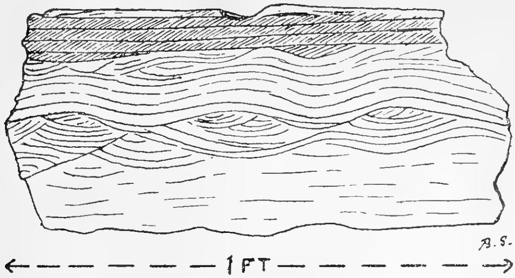


FIG. 2. Stone in south wall of the tower, Fledborough Church, Notts, showing drift-bedding ripples.

In the above example the contorted and brecciated appearance (Fig. 2) seen so frequently in the skerries is reproduced to perfection. It is also to be noted that the laminæ of the dolomitic sandstones are overfolded and tucked away in synclinal form, but no one lamina ever forms a completely closed sphere or ellipsoid as we should expect if the structure was concretionary. In the channel of a stream issuing from a borehole I recently noticed ripple-marks being formed. The sediment was a silt composed of the debris of Coal-measure shales and sandstone and coaly fragments, which formed a deposit not at all pasty; yet pressure of the hand behind some of the ripples caused even this very liquid type of sediment to become contorted or slightly overfolded.

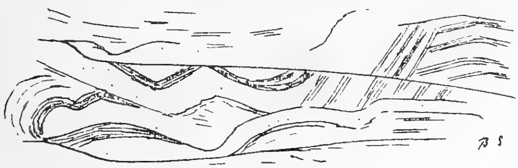


FIG. 3. Stone in wall of Sutton Church, Notts, with broken laminæ. Nat. size.

The idea that the contortions may be due to contraction during dolomitization is dispelled when we remember that the disturbed layer is in many cases both underlain and overlain by a normally ripple-marked layer of identical minerals and percentage composition.

Actual disturbance by water-action is also shown by the occurrence of the above-mentioned pieces of laminated and ripple-marked sandstone in the more compact beds. They have been torn away bodily and carried forward by the rush of muddy water and embedded in curved and twisted patches, which now weather out more easily than the non-laminated matrix.

Depth and Extent of Waters.—Waterstones and Keuper Marls alike were deposited in what was presumably a shallow salt sea or lake of great extent, situated to the east of a southerly projecting spur (the Pennines) of an upland which was under continental climatic conditions; so that in the hot season a great amount of weathering took place in the dry way. In the wet season the debris was swept down into the inland sea, which temporarily increased in extent and depth owing to the influx of fresh water.

All the time that the basin was filling up with sediment the bottom must have been slowly sinking—perhaps most rapidly towards the end of the period—so that the water-level and depth was more or less constant.

The abundance of the skerries in the lower part of the marls and the large deposits of massive gypsum in the higher parts suggests that the waters were deepening and at the same time becoming more saline. But, on the other hand, the skerries never entirely ceased to be formed, and even the higher ones (which contain quartz-grains of two sizes and therefore may indicate deeper water [1]), a long way from the western shore, are ripple-marked and bear salt pseudomorphs; hence the increase in depth must have been trifling. In fact, isostatic conditions seem to have prevailed throughout the area.

The abundance of rather coarse red sandstone, a basal conglomerate, and sandy shales, together with the frequency of salt pseudomorphs, ripple-marks, and sun-cracks,[2] suggests that the Waterstones near their outcrop were accumulated in very shallow water, or even that large tracts with isolated pools were laid bare from time to time. Again, the plant and fish remains found in the Waterstones, and in the Keuper Marls elsewhere, are usually fragmentary, and occur in sediment obviously deposited near a shore-line where the rivers would bring down drift vegetation and render the salt-waters comparatively fresh and suitable for animal life. The fish found by the late E. Wilson at Colwick Wood were supposed by him to have been trapped in the shallows of a lagoon and destroyed either by the waters drying up [3] or becoming increasingly saline. When traced eastward beneath the surface, however, the Waterstones become more like the Marls above them. In a boring at Rampton they were with difficulty separated off from the Marls, and at Lincoln [4] their distinguishing characters are almost wholly absent, only a very little sandstone indeed being present.

Thus in the east we seem to have a more open water area which in the first case was probably quickly flooded, so that the typical shore-line phenomena of the Waterstones were not there developed and the conditions of sedimentation were similar for both Marls and Waterstones.

The thickness of the Keuper between Tuxford and Lincoln is

[1] The coarser sediment of the higher skerries was probably wind-borne to the face of the waters.

[2] I have only seen one slab with casts of sun-cracks from the Keuper Marls of this district.

[3] Dr. H. H. Swinnerton has recently discovered footprints and fish-remains in the Waterstones of Sherwood, Nottingham (Geol. Mag., May, 1910, p. 229).

[4] According to Mr. Henry Preston, Grantham.

remarkably constant (nearly 900 feet), and contrasts strongly with the variable thicknesses encountered near the old shore-line near Nottingham, a fact which once more emphasizes the uniformity of subsidence and isostatic conditions in the centre of the depression.

The presence of massive gypsum near the top[1] of the division at Newark seems to favour the idea that the water also became increasingly saline. The fibrous and platy gypsum in the lower skerry-belts was no doubt deposited as the marls dried and got rid of their included waters.

Source of Sediment.—As to the source of the dolomite, its detrital nature and manner of deposition show that it was not formed where it is now found, but was probably deposited contemporaneously near the shore-line and then swept out by current-action.

Dr. C. G. Cullis recently reported on the occurrence of small isolated rhombs of dolomite[2] in the Keuper Marls of Westbury-on-Severn and as far north as Worcester. The crystals are extraordinarily perfect and always very minute, and occur in both the red and green marl, sometimes in great profusion. A washed residue of the marl contained practically nothing but quartz-grains and these dolomite rhombs; that is to say, the constituent minerals of the skerries are also scattered throughout the shales and marls associated with them. Dr. Cullis is inclined to think that the dolomite rhombs were precipitated directly from solution. They may have been in the first case; in one band at least (from the Waterstones), which was examined microscopically, the dolomite seems to have been formed in situ. In most cases, however, *the rhombs have suffered attrition by being drifted some distance* together with the quartz and other detrital fragments.

The occurrence of grains of dolomitic sandstone in the higher type of skerry is suggestive, as showing that some dolomitic rocks were also exposed to denudation at this time. Most of the quartz and felspar no doubt was derived from Carboniferous sandstones and grits, and to Carboniferous rocks also we must attribute the basis of the finer calcareous and dolomitic shales and marls.

The Finer Deposits.—Just as there are differences in the lithological characters of the skerries, so also the marls themselves differ from point to point and occur in lithological belts of perhaps as great horizontal extent as the skerries. The differences are brought out by the character of the soils on the outcrop. It is well known that the marls contain a high percentage of silica and are practically fine silts: the coarser silts pass into sandy and dolomitic shales or marls, which break down into a sandy soil; the finer ones behave as tough homogeneous clays. Above a skerry it is common to find sandy shales pass gradually upwards into sandy marl, showing ripple-marks, and then into fine homogeneous marl.

Sorby has shown that such homogeneous clays may be deposited either by gentle and uniform currents drifting along fine sediment to spots where there is scarcely any current at all, or to quick deposit of

[1] Massive gypsum is recorded from a lower horizon at Clarborough, north of Retford.

[2] Rep. Brit. Assoc. for 1907, pp. 506, 507.

cohered mud from tranquil waters. The passage from sandy shales to fine marls mentioned above rather favours the first of these alternatives. In addition we must not forget that wind-borne dust and sand would also add largely to the fine sediment. The rate of deposit in muddy rocks may be as much as 9–18 inches per hour according to Sorby, the shaly character of the coarser parts being due to a gentle current of varying velocity carrying sediment of various degrees of fineness.

We may, then, sum up the formation of skerry-belts as follows:—

(*a*) Rather shallow waters slowly becoming desiccated during a dry period; deposition of fine sediment as marl, some possibly wind-borne and distributed by water, for under favourable conditions even the blocky marls show signs of bedding and current-action. Formation of salt crystals in the upper clayey layers.

(*b*) Influx of fresh water bringing sediment. Casts taken of salt crystals, now dissolved out. Formation of skerry by successive freshets of water and current-action.

(*c*) As supply of coarse sediment failed, laminated shales were deposited, finally passing into fine sediment as marl. Conditions repeated for every skerry.

On this idea, other things being equal, *every individual skerry represents a wet spell* of greater or less duration or degree. A skerry-belt might therefore represent a sequence of wet seasons, and we have an explanation of the persistence of the skerry-belts and general types of sediment over large areas whilst the individual skerries are of less extent.

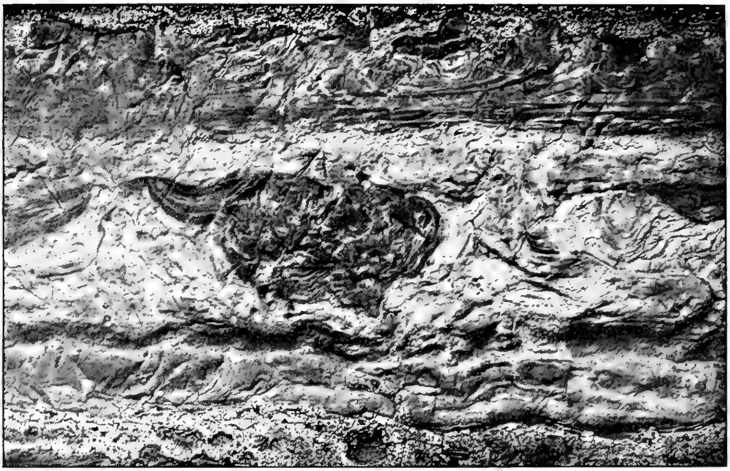
Colour Changes.—A discussion of the variegated colours of the Keuper is beyond the limits of this paper; one or two remarks, however, may not be out of place. We cannot assume that all the red beds were once green, or that all the green beds were once red. There have been changes about tree-roots and along joints where red marl has become green, but the deciding factor for the big colour changes must have been one connected with the mineral solutions in the water and their concentration. In this connexion the above-mentioned gradual change in colour with each skerry when well developed is suggestive. With the influx of fresh waters the conditions which previously brought about a red colour were upset, and a green took its place, followed by alternating red and green conditions until the red finally prevailed as the waters became more concentrated.

Goodchild[1] has pointed out that the presence of organic and humic acids prevents the deposition of iron as ferric oxide—and most of the fossiliferous beds in the Keuper are grey or green. It does not therefore seem too great an assumption to suggest that the first torrential[2] waters sweeping down from the land not only cooled and diluted the previous solutions, but also carried with them organic remains and humic and organic acids which would for a time

[1] "Desert Conditions in Britain": Trans. Geol. Soc. Glasgow, 1898, vol. xi, pt. i, pp. 87, 89, 90.

[2] Especially if humid conditions prevailed in the upper parts of the inland basin as in the case of the Dead Sea and the Great Salt Lake.

1



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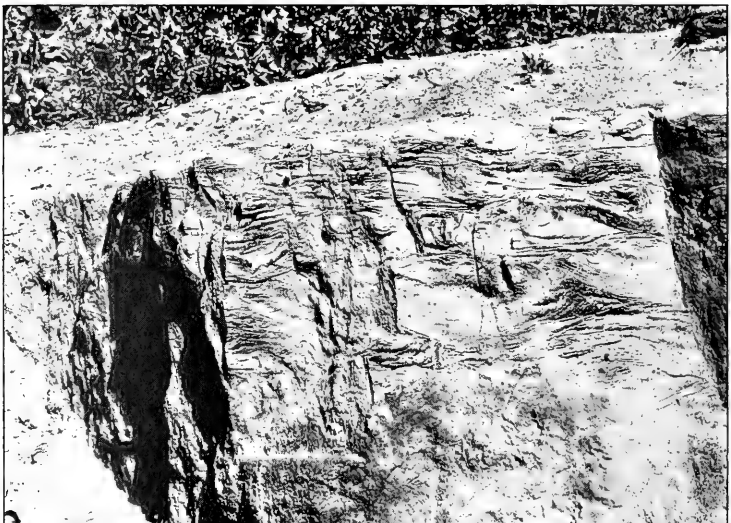

A. W. Rogers.

prevent the formation of red beds and perhaps also bleach the red marl immediately beneath the skerries.

My thanks for criticism and suggestion are due to Mr. G. W. Lamplugh, and to Mr. E. E. L. Dixon whose knowledge of dolomitic rocks is both varied and extensive.

EXPLANATION OF PLATE XXVI.

FIG. 1. Stone, 14 by 7 inches, in the east wall of south porch, Sutton-on-Trent Church, Notts.

,, 2. Broken and contorted alluvial silt in the left bank of the Prieska ravine where it opens on the Orange River.

VI.—*Glyptops ruetimeyeri* (Lyd.), a Chelonian from the Purbeck of Swanage.

By D. M. S. Watson, B.Sc., the Victoria University of Manchester.

THE Manchester Museum contains two 'turtles' from the Middle Purbeck Cap and Feather Bed of Swanage which are referable to Lydekker's[1] *Thalassemys ruetimeyeri*. The first of these, L. 7017, was purchased from Swanage in 1906, and consists of a carapace lacking all the marginals, but otherwise complete and undisturbed. The second, L. 9520, was obtained by the writer from a quarry some 2 miles west of Swanage in March of this year. This specimen, although crushed, is important because it retains the whole shell, both carapace and plastron, with the exception of some of the peripherals.

Description of Specimens.

Carapace (Fig. 1).—The carapace is much depressed and is markedly cordiform. Its length from the anterior end of the nuchal to the posterior border of the last suprapygal is 28 cm., and the maximum width across the third costals is 26 cm. The nuchal is a large hexagonal bone, the anterior edge of which is concave; its dimensions are—length 3 cm., breadth 6·8 cm.

In the two Manchester specimens two distinct bones lie between the inward ends of the first pair of costals; in Lydekker's type-specimen, as is shown in his figure, and as Dr. Andrews has kindly checked for me, there is only one bone occupying the same space.

The first of these bones is probably homologous with that which has been figured by Hay[2] and others in *Chisternon*, *Boremys*, *Aspideretes*, and *Plastomenus* as the præneural; its condition in the present case is very similar to that which obtains in the last three genera. The neurals are generally hexagonal, with the face for the corresponding costal much larger than that for the preceding one. All eight are at present well developed.

Two suprapygals are shown in L. 7017: the first is a hexagonal bone having a short border for the eighth neural and a long curved edge for the second suprapygal. The second suprapygal is quadrilateral and much wider in front. The costals gradually decrease in length from front to back; no pair meets in the middle line, and their form can be best understood from Text-fig. 1.

[1] R. Lydekker, *Catalogue of the Fossil Reptilia in the British Museum (Natural History)*, 1889, vol. iii, p. 149.

[2] O. P. Hay, "The Fossil Turtles of North America": Carnegie Institution, Publ. 75, 1908.

The marginals of the right side of L. 9520 are preserved, although they are somewhat damaged. The fourth, fifth, and sixth have a rounded border; from the seventh to the tenth the edge becomes more and more acute, a change which may be accentuated by the crushing the specimen has undergone. The evidence points strongly to their having been eleven marginals; this is, however, not quite certain owing to the damage L. 9520 sustained at the hands of the quarryman who found it.

The whole surface is enamel-like and polished, the ornament consisting of irregular depressions and ridges; the sutures between bones are crossed by fine striæ at right angles to their direction.

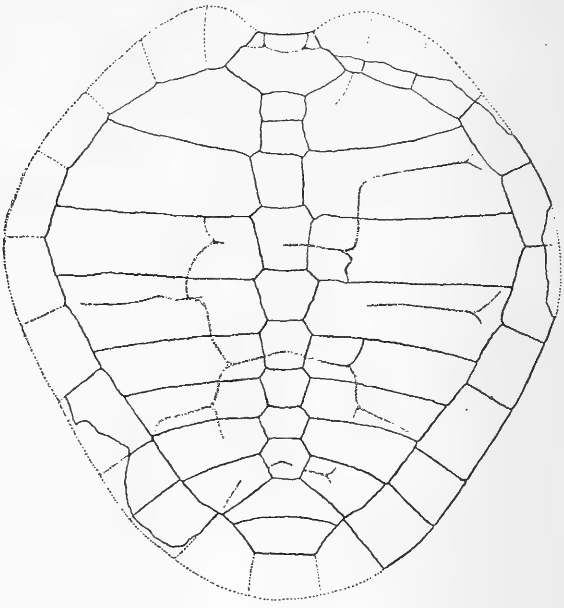

Fig. 1. Restored dorsal view of the carapace of *Glyptops ruetimeyeri* (Lyd.). The bones represented by full lines are present in one or other of the Manchester specimens. The whole carapace within the peripherals is an accurate drawing of L. 7017; the peripherals are added from L. 9520, which is of precisely the same size as L. 7017. The contour of the two anterior peripherals is taken from Lydekker's figure of the type-specimen. I have inserted in the figure all the sulci separating epidermal shields which I have been able to make out on both the Manchester specimens. $\frac{1}{4}$ nat. size.

Plastron.—The plastron is preserved in its natural position in L. 9520; it is flat, and very strongly resembles that of *Pleurosternum*. The anterior end is imperfect, the bridge is long, and the free posterior end narrows until the posterior border ends in a distinct notch.

There are large mesoplastra, which meet in the middle line without appreciably narrowing. The entoplastron was probably rather longer than wide; only a fragment of the left epiplastron remains. The plastron is connected with the carapace by suture of the hyo-, meso-, and hypo-plastra with the fourth to eighth marginals, and probably also by short and narrow buttresses; the evidence for these is that they have formed marked prominences on the carapace during the crushing which the specimen has undergone. The evidence suggests that the axillary buttress came down on to the first costal, and the inguinal buttress was fixed to the fifth and sixth costals at their junction, but chiefly to the sixth.

The sulci marking the limits of the epidermal shields are very obscure and only slightly impressed on the bones. So far as I have been able to determine them they are entered on Text-figs. 1 and 2. The nuchal shield is, however, quite distinct in both the Manchester specimens. The evidence appears to show that there were no supra-marginals and that the marginal shields lapped slightly on to the costals. On the plastron the sulci are easier to make out; there is a series of infra-marginal shields carried almost entirely on the hyo-, meso-, and hypo-plastra.

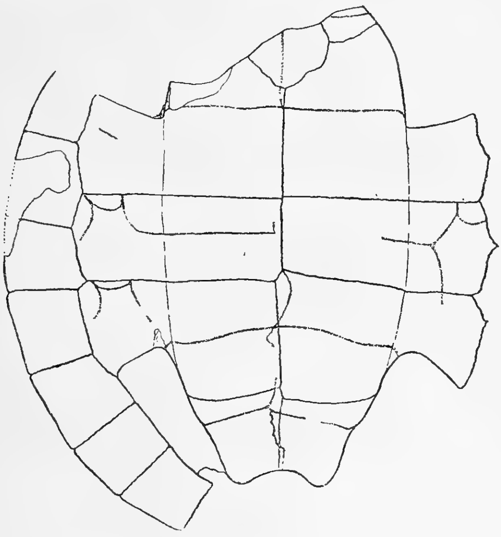

Fig. 2. Plastron of *Glyptops ruetimeyeri* (Lyd.). An unrestored drawing of L. 9520. $\frac{1}{4}$ nat. size.

That the turtle I have described above is identical with Lydekker's *Thalassemys ruetimeyeri* there can be no reasonable doubt; the contour of the carapace and the distribution of the epidermal shields, so far as they can be made out, the form and relations of the nuchal and first suprapygal are very similar, and with the exception of the occurrence of a præneural in the Manchester specimens, such slight differences as there are can be easily accounted for by the fact that the type-specimen is rather smaller than the new specimens, and is therefore presumably rather younger. The plastron, containing as it does large and well-developed mesoplastra, at once removes the species from

Thalassemys and transfers it to the Amphichelydia or Pleurodira. The occurrence of infra-marginals at once puts the Pleurodira out of court.

Hay, in his recent monograph of the fossil turtles of North America, published by the Carnegie Institution, retains two families in the Amphichelydia, the Pleurosternidæ and the Baënidæ. The only differences in the shells of the families are: (1) The Baënidæ have more strongly developed axillary and inguinal buttresses than the Pleurosternidæ; (2) in the Baënidæ the mesoplastra contract strongly as they approach the middle line, whereas in the Pleurosternidæ they retain their full width until they meet. In our species the mesoplastra agree with the condition characteristic of the Pleurosternidæ.

The buttresses cannot be well observed in the Manchester specimens, but judging from the inner aspect of the distal end of the left hyoplastron, which is visible in L. 9520, the axillary buttress must have been small and feeble. Therefore in this character also there is agreement with the Pleurosternidæ. The animal under discussion differs from *Pleurosternum* itself in the presence of a nuchal shield and in the emarginate anterior edge.

The family only contains two other described genera, *Helochelys* and *Glyptops*. *Helochelys* differs markedly from our form in the very loose connexion between the plastron and carapace, and there only remains for comparison *Glyptops*.

This genus was founded by Marsh for a medium-sized Chelonian from the Morrison, Como, or *Atlantosaurus* beds of the United States Upper Jurassic. The type species, *G. ornatus*, is held by Baur to be specifically identical with *Compsemys plicatulus* of Cope. Hay has shown that this species does not belong to the genus *Compsemys*, but represents a very distinct genus for which Marsh's name *Glyptops* must be adopted. Judging from Hay's beautiful figures and excellent description, *G. plicatulus* is extremely similar to our animal: with two exceptions the two agree exactly. The form of the carapace and plastron is similar, the position of the epidermal shields and the ornament are unusually alike; a nuchal shield is said to occur in *G. plicatulus* by Baur. The only differences in fact are these: (1) In our turtle there is sometimes a præneural bone. (2) There are two suprapygals in the English specimens; one of Hay's specimens, the original of his plate vi, is stated to have only one, but his photographic plate shows a crack or suture in a position very similar to that separating the first from the second suprapygal in my specimens. (3) In our turtle the xiphiplastra are rather more deeply notched than in *G. plicatulus*.

The only one of these differences that is at all serious is the first, and as it appears that this difference is liable to occur between individuals of the same species, it can hardly be held to be of generic importance. It thus appears that *Thalassemys ruetimeyeri*, Lyd., should be referred to the genus *Glyptops*, and in future be known as *Glyptops ruetimeyeri* (Lyd.). It deserves to be noticed that *Glyptops* has a large range in time from the Como Beds of the Upper Jurassic to the Denver Beds at top of the Upper Cretaceous; its large range in space is thus rendered much less unlikely.

VII.—The British Earthquakes of the Years 1908 and 1909.

By Charles Davison, Sc.D., F.G.S.

SINCE the Swansea earthquake of June 27, 1906, no strong shock has visited these islands, and, with one exception, all those felt in the years 1908 and 1909 were comparatively slight tremors. The list includes 36 earthquakes, all of them originating in Scotland. The most important were the Dunoon earthquake of July 3, 1908, and the Ochil earthquake of October 20, 1908, the latter being the strongest shock felt in that district during the present century. The remaining tremors occurred in the Ochil district, and the great majority of them would have remained entirely unknown to seismologists had it not been for the interest taken in them by Mr. W. H. Lindsay and Mr. T. J. H. Drysdale of Menstrie, Mr. J. Dempster of Airthrey, and Dr. W. L. Cunningham of Alva. To the courtesy of these gentlemen I am indebted for the principal materials of this paper.

1–7. *Ochil Earthquakes: January* 19 – *June* 21, 1908.

1. January 19, 1908: 1.27 a.m.—A distinct shock, felt at Menstrie. On February 9, 1908, at 4.6 a.m., a shock, stronger than the preceding, was felt at Menstrie, but only, so far as known, by one observer.

2. May 1, 1908: 6.54 p.m.—A shock of intensity 4 felt at Airthrey, Alva, Dunblane, Menstrie, and Tillicoultry. The shock consisted of one maximum, lasted two seconds, and was accompanied by a loud noise like a muffled explosion.

3. May 2, 1908: 7.5 a.m.—A shock of intensity 4, and lasting three seconds, felt at Airthrey, Alva, and Menstrie. At Airthrey the shock consisted of two concussions, connected by tremors, the latter concussion being the stronger. The shock was preceded, accompanied, and followed by a rumbling noise.

4. May 10, 1908: 12.48 a.m.—A shock of intensity 4, and lasting about four seconds, felt at Airthrey, Alva, Menstrie, Tillicoultry, and Tullibody. At Airthrey and Menstrie the shock consisted of two concussions, the first being much the stronger at Airthrey, and of about the same intensity as the other at Menstrie. Each concussion was accompanied by a loud noise like an underground explosion.

5. May 10, 1908: 12.58 a.m.—A slighter shock than the preceding, but of intensity 4, felt at Airthrey, Alva, and Menstrie. At Airthrey the shock appeared to be single; at Menstrie it consisted of two bumps, the first probably the stronger. The shock was accompanied by a muffled sound like that of an explosion.

6. June 21, 1908: 3 a.m.—A distinct single shock felt at Alva and Menstrie, and at the former place accompanied by a loud noise.

7. June 21, 1908: 4.20 a.m.—A slight but distinct single shock, felt at Menstrie.

8. *Dunoon Earthquake: July* 3, 1908.

Time of occurrence, 6.15 a.m.; intensity 4; centre of disturbed area in lat. 56° 6·7′ N., long. 4° 56·5′ W.; number of records 70, from 15 places, and a negative record from 1 place.

The number of records of the time is 67. Of these 20 are regarded as accurate to the nearest minute, and 17 of them agree in indicating 6.15 a.m. as the correct time.

Notwithstanding the large number of records, for which I am chiefly indebted to the kindness of Mr. G. S. Rae of Kilcreggan and Mr. John Robertson, F.R.G.S., of Strachur, the places at which the earthquake was observed are few in number. It is thus impossible to determine the boundary of the disturbed area with any approach to accuracy. Roughly it is an oval curve, 25 miles long, 21 miles wide, and containing about 400 square miles, with its centre 11 miles north of Dunoon and its longer axis directed about N. 41° E.

At most places the shock consisted of a single series of tremors, its average duration being four seconds. At Strachur, however, two parts were felt by four out of eighteen observers, the average interval between them being three seconds, the first part in each case being regarded as the stronger.

The sound was heard by all the observers. In 27 per cent. of the records it was compared to passing wagons, etc., in 29 per cent. to thunder, in 14 to wind, in 15 to loads of stones falling, in 4 to the fall of a heavy body, in 10 to explosions, and in 1 per cent. to miscellaneous sounds. The beginning of the sound preceded that of the shock in 24 per cent. of the records, coincided with it in 72, and followed it in 4 per cent.; the end of the sound preceded that of the shock in 23 per cent. of the records, coincided with it in 67, and followed it in 10 per cent.; the duration of the sound was greater than that of the shock in 18 per cent. of the records, equal to it in 74, and less than it in 8 per cent.

About four years before, on September 18, 1904, a somewhat stronger earthquake (of intensity 5) was felt in nearly the same district. This earthquake disturbed an area of about 564 square miles, the centre of the isoseismal 5 being 9 miles west of Dunoon and lying on the longer axis of the area disturbed by the earthquake of 1908, and at a distance of about 14 miles in a south-westerly direction from its centre.[1] It is thus very probable that the two earthquakes are connected with the same parent fault, and that the movement along this fault in 1904, while relieving the stress in the portion west of Dunoon, increased the stress in the neighbouring portion of the fault, and thus prepared the way for the movement four years later in the district to the north of Dunoon.

9–14. *Ochil Earthquakes: July* 17 – *October* 20, 1908.

9. July 17, 1908: 5.27 p.m.—A slight but distinct tremor, felt at Alva and Menstrie, and accompanied by noise. Another, but still slighter, shock is said to have been felt at Menstrie after 9 p.m. on the same day; but, as I have no direct evidence from that place, it should be regarded as of doubtful seismic origin.

10. September 2, 1908: 8.16 a.m.—A single shock, of intensity 3, felt at Menstrie, and accompanied by a rumbling noise.

11. September 2, 1908: 8.51 a.m.—A single shock, of intensity 3, felt at Menstrie, and accompanied by a rumbling noise.

[1] Geol. Mag., 1908, Vol. V, pp. 297–8.

12. October 16, 1908: 9.53 p.m.—A tremor, of intensity 4 and duration two seconds, felt at Airthrey, Alva, Blair Ochil (Dunblane), Menstrie, and Red Carr. At Airthrey the shock consisted of one part, at Menstrie of two prominent vibrations or bumps. The sound is compared to an underground explosion, a clap of thunder, or the thud of falling rock.

13. October 19, 1908: 9.18 a.m.—A slight tremor, with sound, observed at Airthrey. The shock was also felt at Blair Ochil (Dunblane).

14. October 19, 1908: 9.39 a.m.—A noise, without any accompanying tremor, heard at Menstrie.

15. *Ochil Earthquake: October* 20, 1908 (*Principal Earthquake*).

Time of occurrence, 4.8 p.m.; intensity 7; centre of isoseismal 6 in lat. 56° 11·4′ N., long. 3° 47·3′ W.; number of records 59, from 34 places, and 20 negative records from 18 places.

This is probably the strongest of all recorded earthquakes in the Ochil district. The intensity was not less than 7 at Alva and Tillicoultry, while that of the earthquake of September 21, 1905, was at no place higher than 6.

Of thirty-six records of the time, eight are regarded as being accurate to the nearest minute. The average of these is 4.8 p.m., which agrees with the majority of estimates.

The only isoseismal which it is possible to draw is that of intensity 6, and this agrees so closely with the corresponding isoseismal of the earthquake of September 21, 1905, that it is unnecessary to reproduce it.[1] Towards the north, west, and south the two curves are almost coincident; towards the east the isoseismal of the later earthquake falls short of the other by about half a mile. Its length is 15 miles, width 10½ miles, and area 123 square miles. Its centre is 3½ miles E. 48° N. of Menstrie, and the direction of its longer axis E. 25° N. The magnitude of the disturbed area is unknown, but it is probably nearly the same as that of the earthquake of September 21, 1905, though slightly displaced to the south, for the shock was felt at several places, such as Falkirk, Polmont, and Bo'ness, which are from one to two miles south of the isoseismal 4 of the earthquake of 1905, while it was not felt at Comrie, Monzie, and Crieff, close to the northern portion of the same curve. From the district lying to the south of the last-mentioned places observations are altogether wanting.

At several places within the isoseismal 6 (such as Alloa, Cambus, Greenloaning, Menstrie, and Tillicoultry) the shock consisted of two distinct parts, separated by an interval of about three seconds, the first part being much the stronger. At other places farther from the epicentre one part only was observed, the effect resembling that caused by the fall of a heavy weight or by the passage of a traction engine. The average of fifteen estimates of the duration of the shock is 2¾ seconds.

The sound accompanying the shock was heard by 92 per cent. of

[1] See Quart. Journ. Geol. Soc., 1907, vol. lxiii, pl. xxvi.

the observers. In 47 per cent. of the records it is compared to passing wagons, etc., in 27 per cent. to thunder, in 17 to the fall of a heavy body, and in 10 per cent. to explosions. The beginning of the sound preceded that of the shock in 33 per cent. of the records, coincided with it in 54, and followed it in 13 per cent.; the end of the sound preceded that of the shock in 19 per cent. of the records, coincided with it in 33, and followed it in 47 per cent.; the duration of the sound was greater than that of the shock in 39 per cent., equal to it in 39, and less than it in 22 per cent.

16. *Ochil Earthquake: October* 20, 1908, 4.13 *p.m.*

Intensity 5; centre of disturbed area in lat. 56° 11·3′ N., long. 3° 48·0′ W.; number of records 18, from 13 places.

The boundary of the disturbed area coincides nearly with the isoseismal 6 of the preceding earthquake, except that it is displaced about half a mile to the west-south-west. The area is 15 miles long, 10½ miles wide, and contains about 123 square miles. Its centre is 3 miles E. 50° N. of Menstrie and half a mile west-south-west of that of the isoseismal 6 of the preceding earthquake, and its longer axis is directed E. 25° N. The intensity of the shock was greatest (namely, 5) at Tillicoultry. The shock was merely a brief tremor, lasting about 1½ seconds, without any prominent vibration or 'thud'. The sound, which attracted but little attention, was compared to thunder or an explosion.

17–36. *Ochil Earthquakes: October* 20, 1908 – *October* 22, 1909.

17. October 20, 1908: 9.26 p.m.—A very slight shock felt at Airthrey and Menstrie. At Airthrey the sound and vibration began together, and terminated simultaneously in a thud.

18. November 6, 1908: 4.45 p.m.—A noise heard at Menstrie.

19. January 19, 1909: 5.28 a.m.—A shock, of intensity 4, felt at Airthrey, Alva, and Menstrie, accompanied by a loud sound.

20. January 19, 1909: 5.29 a.m.—A shock, felt at Menstrie. At Alva two tremors were felt after the shock at 5.28 a.m., but the times are not known.

21. January 23, 1909: 12.15 p.m.—A slight concussion, of intensity 3, felt at Airthrey and Menstrie, accompanied by a noise like that of an explosion underground.

22. January 24, 1909: 12.15 p.m.—A shock, of intensity 3, felt at Menstrie.

23. January 24, 1909: 2.28 p.m.—A tremor felt at Airthrey.

24. January 24, 1909: 3.35 p.m.—A tremor, of about the same intensity as the preceding, felt at Airthrey.

25. January 27, 1909: 1.40 p.m.—A slight shock felt at Menstrie.

26. February 22, 1909: 7.26 p.m.—A noise heard at Menstrie.

27. March 19, 1909: 9.35 a.m.—A shock, accompanied by noise, felt at Menstrie.

28. May 22, 1909: 3.23 p.m.—A shock, of intensity 5, felt at Airthrey and Menstrie; accompanied by a sound like that of an explosion.

29. May 22, 1909: 5.1 p.m.—A shock, of intensity 4, felt at Airthrey; accompanied by a noise like that of a slight explosion.

30. May 22, 1909: 5.24 p.m.—A slight shock felt at Menstrie.

31. May 22, 1909: 8.23 p.m.—A shock, of intensity 5, felt at Airthrey; accompanied by a sound like that of an explosion, the sound being louder than at 5.1 p.m.

32. October 21, 1909: 8.37 a.m.—A concussion, of intensity 4, felt at Airthrey, and followed by a sound like that of an explosion.

33. October 21, 1909: 9.53 a.m.—A slight shock felt at Menstrie.

34. October 22, 1909: 6.55 a.m.—A slight shock felt at Menstrie.

35. October 22, 1909: 7.57 a.m.—A concussion, of intensity 4, felt at Airthrey, preceded and followed by a sound like that of a heavy body falling.

36. October 22, 1909: 9.8 p.m.—At Airthrey, three concussions, separated by intervals of two and five seconds, preceded and followed by sounds like those of sharp explosions.

Origin of the Ochil Earthquakes.

From the only isoseismal line that can be drawn of the earthquake of October 20, 1908, it may be inferred that the direction of the originating fault is about E. 25° N., which agrees closely with that of E. 27° N. obtained from the earthquakes of July 23 and September 21, 1905. The corresponding direction given by the first earthquakes of the present series, those of September 17 and 22, 1900, is E. 11° N. They originated, however, in a more westerly region, so that it is uncertain whether two faults have been in action or a single fault with varying direction.

The Ochil fault passes through or near the Hillsfoot villages, at which alone the slighter shocks were felt, and has a mean direction there of about E. 13° N. Moreover, at several of these places (Menstrie, Alva, and Tillicoultry especially) the shocks attained an intensity which is out of all proportion to the areas disturbed. For instance, the earthquake of October 20, 1908, disturbed an area of about 1000 square miles, while the average area disturbed by a British earthquake of the same intensity is about 27,000 square miles. This points to an extremely shallow origin for the Ochil earthquakes, and therefore favours their connexion with the great fault of the district.

With regard to the hade of the fault, the seismic and geological evidence are at first sight apparently in conflict. In the neighbourhood of Dollar, which is about four miles east of Tillicoultry, it is known to hade to the south. In the district in which the earthquakes originate, that between Airthrey and Tillicoultry, both the course and hade of the fault are unknown. That the originating fault here hades to the north is, however, clear from the relative positions of the isoseismal lines of the earthquake of September 21, 1905, and from the fact that by far the larger portion of the disturbed areas of several of the slighter shocks[1] lies on the north side of the fault. Either, therefore, the great fault changes hade between Dollar or Tillicoultry, or there is another fault in its immediate neighbourhood

[1] Such as those of September 17 and 22, 1900; July 23, October 8, December 28 and 30, 1905; and October 20 (4.13 p.m.), 1908.

which hades towards the north and which is responsible for the stronger earthquakes of the series.

Earth-shake at Stanhope (Weardale): December 2, 1909.

An earth-shake was felt in the mining district of Upper Weardale shortly after 11 a.m. So far as can be judged from the small number of records, the disturbed area was about 7 miles in diameter and about 39 square miles in area. The centre is approximately in lat. 54° 45·1′ N., long. 2° 5·0′ W., or 3 miles west of Stanhope. The shock consisted of one series of vibrations, of intensity 4, and lasting about two seconds. The sound was compared to a heavy train passing, the fall of snow from the roof, or the firing of a heavy shot in a quarry. At Boltsburn a vibration, accompanied by a heavy rumble, was felt in two parts of the mine, and it was at first thought that a heavy fall had occurred.[1] The small disturbed area, the nature and brevity of the shock and sound, and the disturbance in the mine at Boltsburn, all point to a superficial slip precipitated by the working in the mines as the cause of the earth-shake.

Spurious Earthquakes.

Tiverton district: May 25, 1909.—At about 12.55 p.m. shocks were felt at several places in East Devon between Honiton and Tiverton. Windows rattled violently, and indoors tremors were felt, which lasted, with short intermissions, for 15 minutes. At Uffculme a peculiar noise, unlike thunder, was heard for 7 minutes. At other places the sound was compared to the rumbling of heavy guns. That this was the origin of the disturbance is clear from the evident transmission of the waves through the air, the long duration of the disturbance, the nature of the sound, and from the fact that at the time mentioned heavy gun-firing took place in the Channel off Weymouth. Honiton is 35 miles and Tiverton 50 miles west-north-west of Weymouth.

Uyeasound (Shetland Islands): October 9, 1909.—A disturbance, supposed to be that of an earthquake, was felt at Uyeasound, in the island of Unst, at about 2.10 a.m. The shock, which was of intensity 5, consisted of two parts, separated by an interval of 9 seconds. The first and stronger part lasted 28 seconds, and the second 12 seconds. The accompanying sound resembled the noise of wheelbarrows, changing, about the time when the shock was strongest, to that of heavy wagons passing.

So far as I can ascertain, the disturbance was noticed by only a few persons. The duration of the double disturbance is of course far too great for a British earthquake, but observers of a true earthquake occasionally err quite as widely in their estimates. It seems clear, however, that a shock so strong as that reported would have been felt by many persons over a wide area. It is possible that it was caused by thunder, which is said to have been heard the same morning.

[1] I am indebted to the kindness of my former teacher, Professor G. A. Lebour, for the first records of this earth-shake.

REVIEWS.

I.—Catalogue of the Fossil Bryozoa in the Department of Geology, British Museum (Natural History). The Cretaceous Bryozoa, Vol. II. By J. W. Gregory, D.Sc., F.R.S., F.G.S. 8vo; pp. xlviii, 346, 9 plates, and 75 figures in the text. London: printed by order of the Trustees of the Museum, 1909.

THIS volume is the third of a series by Dr. Gregory on the fossil Bryozoa in the National Museum at South Kensington: the first, comprising the forms from Jurassic strata, appeared in 1896; the second, published in 1899, and that now under notice contain descriptions of forms from Cretaceous rocks. The delay of ten years in the appearance of the second part of the Catalogue of Cretaceous Bryozoa has arisen from the retirement of Dr. Gregory from the British Museum and his absence from Europe for several years. In this interval the Museum collections have largely increased, but these later additions, with some special exceptions of species of systematic importance, have not been treated in detail in the present work, but remain over, together with the Cheilostomata, for description in the final volume of the Catalogue, which will be prepared by Mr. W. D. Lang, now in charge of the fossil Bryozoa in the Museum.

At the beginning of the present volume the author contributes an elaborate "Introduction to the Cretaceous Bryozoan Fauna", which, but for various obstacles, should have appeared in the previous volume. It is of a somewhat general character, and deals with many points of interest in connexion with the development of the group during this geological period, some of which may be mentioned.

The author is of opinion that the chief modern types of Bryozoa had their origin in the Cretaceous era, and that a separation line between the Palæobryozoa and Neobryozoa might be drawn most appropriately between the Jurassic and the Cretaceous. The following three orders of Bryozoa pass upwards from the Jurassic into the Cretaceous:—

1. Trepostomata, which comprises forms with a massive zoarium of tubular zoœcia. This order is very numerously represented in Palæozoic rocks, and Gregory has placed in it many Jurassic species and states that it is abundant in the Lower Cretaceous, but both rarer and smaller in the Upper, and it is continued into the Cainozoic. Ulrich, however, the founder of the order, holds that there is no evidence that the group survived later than the Palæozoic era,[1] and he relegates to the Cyclostomata many of the genera which Gregory has transferred to the Trepostomata.

2. Cyclostomata. The Bryozoa of this order are very numerous, and they are predominant in the Cretaceous rocks; the author divides it into the three sub-orders of Tubulata, Dactylethrata, and Cancellata.

3. Cheilostomata. This order makes its first appearance in the Jurassic, but only two species are known in this epoch; it first

[1] Zittel, *Text-book of Palæontology*, Eastman's translation, p. 290.

became important in the Upper Cretaceous, and it is the predominant group of Bryozoa in existing seas.

Under "Descriptive Nomenclature" the author defends his use of the term 'gonocyst' for a peculiar type of ovicell in some of the Cyclostomata on the ground that it differs from a 'gonœcium' in not being due to the modification of a single zoœcium; but Dr. S. F. Harmer, who has worked so extensively on the development of existing Cyclostomatous Bryozoa, raises the objection that in all Cyclostomata the ovicell is probably a modified zoœcium, and therefore declines to accept the term proposed. Dr. Gregory further introduces the word 'epizoarium' instead of 'epitheca', borrowed from the nomenclature of corals, which is considered unsuitable as there is no theca in Bryozoa, and the layer is more important and varied in its functions in this latter group than in corals. 'Cancelli' is another term to which different meanings have been attached; by some it refers to aborted zoœcia in dimorphic zoaria; these, however, are now named 'mesopores' by Dr. Gregory, and cancelli are defined as "spaces of interzoœcial origin which remain either as simple or branched tubuli, or as maculæ, round spots or spaces, in the walls of the zoœcia". But in certain cases, as in the Discoporellidæ (Lichenoporidæ) for example, there is great difficulty in determining whether the small pores are of the nature of 'cancelli' or 'mesopores': if the former, the family would be placed in the C. Cancellata; if the latter, in the Trepostomata!

Dr. Gregory then gives a general sketch of the various classifications proposed for the Cyclostomata by the principal authorities on this group from D'Orbigny onwards, and remarks that it shows an unusually complete divergence of opinion as to the number of subdivisions required and as to their respective affinities. The summary of fifty years' work indicates that a more complex classification is necessary for the fossil fauna than for the living members of the group. It would be possible to work out several different classifications of the Cyclostomata according to the values placed on the various characters. "Thus the nature of the zoarium, the general shape of the zoœcium, the linear, radial, or irregular arrangement of the zoœcia, and the solid or cancellous structure of the skeleton, might each be used as the primary systematic character." Until more is known of the succession and geological distribution of the various forms, any classification of the Cyclostomata must be considered as experimental. That adopted by the author as the most suitable is based partly on zoarial and partly on zoœcial characters, the former being used generally for the families and genera and the latter for the sub-orders. Three chief types of zoœcia are recognized—

(*a*) Simple, tubular, monomorphic zoœcia with solid walls.
(*b*) Zoœcia monomorphic, having walls perforated by cavities—the cancelli.
(*c*) Zoœcia dimorphic, one set being aborted to form supporting elements in the zoarium.

The author is of opinion that the recent zonal collecting in the English Chalk by Dr. Rowe and others shows that the Bryozoa are often restricted in their range of distribution, and thus of value as zonal fossils. The view formerly held that their specific life was prolonged and that consequently they were of little or no use in marking zones was due to unreliable determinations of species.

The Systematic Description in this volume includes first the Cretaceous Cyclostomata which were not treated in the first volume. Of these the families belonging to C. Tubulata are the Crisiidæ, Theonoidæ, Fascigeridæ, and Osculiporidæ, and to C. Cancellata the family of the Desmeporidæ. The families included in the order Trepostomata are the Cerioporidæ, Heteroporidæ, Zonatulidæ, Radioporidæ, and Cameroporidæ. In the sub-class Phylactolæmata the family Plumatellidæ. There are also additions and corrections to the following families of the Cyclostomata which were described in the previous volume: Diastoporidæ, Idmonidæ, Entalophoridæ, Eleidæ, Horneridæ, Petaloporidæ, and Clausidæ.

In the descriptions of species the same lines are followed as in the earlier parts of the Catalogue; there is first a full Synonymy, then the Diagnosis, Dimensions, Distribution, Figures, and Affinities of the species. Then follows a List of the Museum Specimens of the particular species described, giving the registered number and details of form and size of one or more specimens included under this number; the formation, zone, and locality whence they come; and lastly, the name of the donor or of the collection to which they formerly belonged. Occasionally the specimens under one number are so many as to preclude any attempt to refer to them individually—for example, in "D. 3367. More than 100 specimens".

Dr. Gregory includes in the Catalogue descriptions or references to all known species of Cretaceous Bryozoa, whether represented or not in the Museum Collection, and altogether in this volume 308 species belonging to 67 genera are enumerated. But of this number the collection possesses specimens of only 103 species and 38 genera. Some of the unrepresented forms are known to be of a dubious character, and others may possibly be found in the recently acquired materials not yet fully examined; but allowing for these, it would seem that there are many significant gaps in the collection yet to be filled up.

A very useful List of Chief Localities for Cretaceous Bryozoa (excluding England) and a comprehensive Bibliography are appended. The Subject Index and the carefully drawn up Index to systematic names of Bryozoa afford every facility for reference to the forms described. The figures in the nine plates are excellently drawn; a greater number of plates to allow of further illustrating the interior structure of some of the forms, more particularly of the Trepostomata, would have been desirable.

Students of fossil Bryozoa are greatly indebted to Dr. Gregory and to those who have helped him in the preparation of this and the previous volume on the Cretaceous forms, and they will hail with satisfaction the early completion of the final volume now in the capable hands of Mr. W. D. Lang.

II.—Fossil Plants: A Text-book for Students of Botany and Geology. By A. C. Seward, M.A., F.R.S., Professor of Botany in the University, Fellow of St. John's College, and Hon. Fellow of Emmanuel College, Cambridge. Vol. II.[1] pp. xxii+624, with 265 illustrations. Cambridge: the University Press, 1910 (C. F. Clay, Manager, Fetter Lane, E.C.). Price 15*s.*

WE gladly welcome the arrival of the second volume of this important work, and none the less so that we have waited long and patiently for its advent. In the first volume more than 100 pages are occupied in general matters introductory to a study of fossil plants both from a geological and a botanical aspect. These are followed by a chapter on the Thallophyta, embracing all the simplest forms of vegetative structures—Diatoms, Coccospheres, Rhabdospheres, and the like; Algæ, *Girvanella*, *Schizomycetes*, *Ovulites*, *Chara*, and many others. Then come the Bryophyta, Liverworts, Mosses, etc., followed by the Pteridophyta, or Vascular Cryptogams, and the Equisetaceæ; these are continued into and concluded in vol. ii. Here are also placed the doubtful fossil forms, the Psilotales. The Equisetites of the Secondary rocks and their predecessors, *Phyllotheca*, *Schizoneura*, etc., of Triassic and Permo-Carboniferous times, are here described and figured, and the Equisetales, represented by the numerous forms of *Calamites* of the Coal-measures with their wonderful stem-structures, leaves, and spore-bearing cones (strobilites), and *Sphenophyllum*, upon which genus the late Professor Williamson devoted so much patient investigation. They form the concluding chapter in vol. i and the opening chapter in vol. ii. Here is also added an account of the spore-cone of *Cheirostrobus*, Scott. These embrace a most interesting group of fossil plant-remains in which the structure has been preserved in a marvellously perfect manner.

The two recent genera, *Psilotum* and *Tmesipteris*, are usually spoken of as members of the family Psilotaceæ, which is included as one of the subdivisions of the Lycopodiales. It is probable, as Scott first suggested, that these two plants are more nearly allied than are any other existing types to the Palæozoic genus *Sphenophyllum*. *Psilophyton*, another rather obscure fossil plant from the Devonian and Silurian rocks of Canada, is placed near the foregoing, but its true botanical relations are a little uncertain.

The Lycopodiales, like the Equisetales and Calamiteæ, present to us plants having recent representatives and also a great and important series of fossil genera. "A general acquaintance with the extinct as well as with the recent Lycopodiales will enable us to appreciate the contrast between the living and the fossil forms, and to realize the prominent position occupied by this group in the Palæozoic period, a position in striking contrast to the part played by the diminutive survivors in the vegetation of the present day" (p. 30). From the modern club-moss *Lycopodium*, the *Selaginella*, and the *Isoetes*, all humble ground-plants, we pass to Arborescent Lycopodiales, *Lepidodendron* and *Sigillaria*, often spoken of as "Giant Club-mosses", and

[1] Vol. i appeared in 1898 (pp. vii, 452, with 111 illustrations, 12*s.*), and was reviewed in the Geological Magazine for May, 1898 (pp. 228-32)

forming by far the larger part of the forest-like vegetation of the Coal-measures all the world over.

"The genus *Lepidodendron* included species comparable in size with existing forest trees. A tapered trunk rose vertically to a height of 100 feet or upwards from a dichotomously branched subterranean axis, of which the spreading branches, clothed with numerous rootlets, grew in a horizontal direction probably in a swampy soil or possibly under water. A description by Mr. Rodway of Lycopods on the border of a savannah in Guiana, forming a miniature forest of pine-like Lycopodiums, might, with the omission of the qualifying adjective, be applied with equal force to a grove of *Lepidodendra.* The equal dichotomy of many of the branches gave to the tree a habit in striking contrast to that of our modern forest trees, but, on the other hand, in close agreement with that of such recent species of *Lycopodium* as *L. cernuum, L. obscurum,* and other types. Linear or oval cones terminated some of the more slender branches, agreeing in size and form with the cones of the spruce fir and other Conifers or with the male flowers of species of *Araucaria,* e.g. *A. imbricata.* Needle-like leaves, varying considerably in length in different species, covered the surface of the young shoots in crowded spirals, and their decurrent bases or leaf-cushions formed an encasing cylinder continuous with the outer cortex. The fact that leaves are usually found attached only to branches of comparatively small diameter would seem to show that *Lepidodendron,* though an evergreen, did not retain its foliage even for so long a period as do some recent Conifers" (p. 93).

"By the activity of a zone of growing tissue encircling the cylinder of wood, the main trunk and branches grew in thickness year by year: the general uniformity in size of the secondary conducting elements affords no indication of changing seasons. As the branches grew stouter and shed their leaves the surface of the bark resembled in some degree that of a spruce fir and other species of *Picea,* in which the leaf-scars form the upper limit of prominent peg-like projections, which, at first contiguous and regular in contour, afterwards become less regular and separated by grooves, and at a later stage lose their outlines as the bark is stretched to the tearing-point. The leafless branches of *Lepidodendron* were covered with spirally disposed oval cushions, less peg-like and larger than the decurrent leaf-bases of *Picea,* which show in the upper third of their length a clean-cut triangular area, and swell out below into two prominent cheeks separated by a median groove, and tapering with decreasing thickness to a pointed base which in some forms (e.g. *Lepidodendron Veltheimianum*) is prolonged as a curved ridge to the summit of a lower leaf-cushion" (p. 94).

"A fully grown *Lepidodendron* must have been an impressive tree, probably of sombre colour, relieved by the encircling felt of green needles on the young pendulous twigs. The leaves of some species were similar to those of a fir, while in others they resembled the filiform needles of the Himalayan Pine (*Pinus longifolia*)" (p. 95).

An interesting explanation is offered of the circular linear scars (*Ulodendron* and *Halonia*) seen on the stem of certain *Lepidodendra* (e.g. *L. Veltheimianum*), and which Mr. Watson, of Manchester, has regarded as a branch-scar. This hypothesis is further supported by M. Renier, who describes a specimen of *Bothrodendron* from Liège giving indisputable evidence that the scar represents the base of the branch (p. 133). The structures of the spore-bearing cones and the scar and stem-structures of both *Lepidodendron* and *Sigillaria* are elaborately illustrated and clearly described by the author.

As bearing upon the probable aquatic habit of the roots of *Lepidodendron* and *Sigillaria*, known by the name *Stigmaria*, met with so abundantly in the underclays of the Coal-measures, it may not be without interest to record that when the great water-lily lake in Mr. James Yates' garden at Hampstead was drained many years ago, the floor was found to be carpeted with a vast interlaced mass of the roots of *Nymphæa alba* and *Nuphar lutea*, which might have been easily imagined to be *recent* living examples of *Stigmaria ficoides*, their surfaces being covered with circular scars bounded by a raised rim and containing a small central pit. These scars are the bases of attachment of rootlets, and are often to be seen radiating through the shale or sandstone, once forming the muddy semi-aquatic soil on which these Carboniferous forest trees actually grew.

From the forest trees of the Coal we pass to the Filicales, the fossil ferns whose beautiful forms are to be seen often in the roof-shales of our productive Coal-measures. But space does not permit us to dwell upon them here; they fill 300 pages, and deserve a very careful and full notice. Many forms met with in Oolitic shales and in the Wealden are recorded by Professor Seward, as well as the rich series from the Coal-measures. They have more than 100 excellent illustrations to their share.

But we do not permanently part company with Professor Seward, for in his preface he announces his intention to give us a *third* volume to embrace the *Pteridosperms*, other than those briefly described in the final chapter of the present volume, and also other classes of *Gymnosperms*. We are likewise promised some discussion on the fascinating subject of the geographical distribution of plants.

The story of the past floras of the earth, interwoven as it is with that of its living plants, is like the Indian story-tellers' recitals, which last for many days, but we promise Professor Seward—if he does not delay his third volume too long—we will give it as cordial a welcome as we have done vols. i and ii already before the public.

III.—Memoirs of the Geological Survey of England and Wales.

The Geology of the South Wales Coal-field. Part X: The Country around Carmarthen. By A. Strahan, Sc.D., F.R.S., T. C. Cantrill, B.Sc., E. E. L. Dixon, B.Sc., and H. H. Thomas, M.A.; with notes by B. S. N. Wilkinson. 8vo; pp. viii, 177, with 18 text-illustrations. London, 1910. Price 2*s*.

THE area described in this memoir is wholly in the county of Carmarthen, and it is included on Sheet 229 of the colour-printed Geological Survey map. Two editions of this sheet accompany the memoir, the one with and the other without the Boulder-clay and associated glacial sand and gravel. The drifts do not very seriously obscure the sequence and structure in the Palæozoic rocks which form the foundation of the entire area, and the Drift map will therefore be most useful to geologists. The price of each map is 1*s*. 6*d*.

The geological formations include the Upper Tremadoc of the Cambrian, the Ordovician from the Arenig to the Upper Bala, the Lower Llandovery of the Silurian, the Old Red Sandstone, and the Carboniferous rocks up to the lower part of the Pennant Grit.

The general structure of the area is shown on sections printed on the margin of the map, and here we note that there is some inconsistency in the nomenclature adopted, most of the divisions being indicated by their stratigraphical names, such as Tremadoc Beds and Redhill Beds, others by zonal (graptolitic) names. We think the term Arenig shales would have been better than Tetragraptus Beds from a practical point of view.

A most difficult country is that in the northern part of the area, where the Lower Palæozoic rocks are folded, inverted, and faulted, and shales of different ages and sometimes of similar character are brought into abrupt contact; but the authors have thoroughly elucidated the geological structure by their careful and detailed researches in the field, by the collection of fossils, and with the aid of Dr. Ivor Thomas in the Museum at Jermyn Street, of Mrs. Shakespear in the determination of the Graptolites, of Mr. P. Lake with regard to Trilobites, and of Dr. C. A. Matley with Brachiopods. Most of the disturbances affecting the Lower Palæozoic rocks took place prior to the deposition of the Old Red Sandstone, and between these groups there is everywhere great unconformity.

Remains of *Cephalaspis* and *Pteraspis* are recorded from the Lower Old Red Sandstone; and some plant-remains, *Artisia* and *Stigmaria*, identified by Dr. R. Kidston, have been found in the Penlan quartzite near Kidwelly, a rock assigned to the Upper Old Red Sandstone. The complex zonal divisions in the Carboniferous Limestone Series are described, and attention is then directed to the Millstone Grit and Coal-measures, which occupy the south-eastern portion of the area and form the western part of the main South Wales Coal-field. A small tract of the less productive coal-field which extends into Pembrokeshire is shown on the western margin of the map. The details in the Lower Coal Series form the most important practical part of this memoir. There are also notes on various economic products, including lead-ore, silica-stone (used for making fire-bricks), building-stones, etc.

Among Drift deposits the occurrence is mentioned of two patches of sand at an altitude of more than 500 feet above sea-level east of Eglwys-Cymmyn. A shaft was sunk in 1906 to ascertain the nature of the strata, and 30 feet of sand, loam, and gravel were penetrated. It is noted that the sand contains an assemblage of minerals almost identical with that which was determined by Mr. H. H. Thomas in the Lower Pliocene Sands of St. Erth and St. Agnes in Cornwall. No fossils were obtained from the Welsh strata, which may have been deposited during the Glacial Period.

IV.—Transvaal Mines Department, Geological Survey.

The Geology of the Pilgrims Rest Gold Mining District. By A. L. Hall, B.A., F.G.S. 8vo; pp. 158, with 20 text-illustrations, 33 plates, and geological map. Pretoria, 1910. Price 7*s.* 6*d.*

IN addition to the admirable reports issued annually since 1903 by Mr. H. Kynaston, the Director of the Geological Survey, five separate memoirs on special areas, accompanied by colour-printed geological maps, have been issued. The latest of these memoirs, No. 5, is the one now before us. The map represents portions of the Lydenburg, Zoutpansberg, and Barberton Districts, an area of about 2600 square miles. The geological formations belong mostly to the Transvaal System: a great series of shales, sandstones, and quartzites, dolomitic limestone and chert, in ascending order, divided into the Black Reef Series, Dolomite Series, and Pretoria (or Lydenburg) Series. These rocks are generally grouped as pre-Devonian, or as pre-Cape rocks, their age being somewhere between Devonian and Archæan. Correlation is not attempted in the memoir.

As a gold-producing district that of Pilgrims Rest ranks in the Transvaal next after the Rand, the output for the year 1909 amounting to a little over £400,000 in value. Mr. Hall remarks that the reefs occur more especially in the Dolomite and Black Reef Series, and mostly as "interbedded ore sheets, and thus behave stratigraphically exactly like the sedimentary strata in which they lie". Apart from these "flat reefs", there are less important "cross reefs" which strike across the formations. The author, however, points out that "certain features are persistent and characterize both varieties of reefs. These are the essentially quartzose nature of the reef and the constant association with metallic sulphides, notably pyrites and occasionally copper ores. It is therefore probable that the principles controlling their formation are essentially the same". He concludes that "the gold was introduced in soluble form by the circulation of underground waters carrying silica and iron in solution, the gold being precipitated mainly as the result of the reduction of the iron to the ferrous condition".

Full particulars are given of the strata, and of the intrusive and contemporaneous igneous rocks in the Transvaal System. The geological structure is shown in a number of sections, and the physical features and rock-structures are represented in a series of excellent photographic plates. Among these is a fine view of the Devil's Window, north of Belvedere, in the escarpment of the Drakensberg, looking towards the low country.

V.—Colonsay, one of the Hebrides: its Plants, their local names and uses; Legends, Ruins, and Place-names; Gaelic names of Birds, Fishes, etc.; Climate, Geological Formation, etc. By Murdoch McNeill. pp. vii, 216. Edinburgh: David Douglas, 1910. Price 2*s.* 6*d.* net.

COLONSAY with its adjunct Oransay, for they are connected for several hours during low water, is about 12 miles in length and 3 in breadth. As represented on Sir Archibald Geikie's map of

Scotland, the joint island is formed mainly of Torridonian grits and flags, with Lewisian gneiss in the north, and elsewhere small areas of limestone, eruptive rocks, and raised beach. A more detailed geological sketch-map was published by Mr. W. B. Wright in 1908,[1] based on field-work carried out in the course of the geological survey by Mr. E. B. Bailey and himself. It would have been well if this map had been reproduced in the volume before us, especially as the author acknowledges help from Mr. Bailey, who has "corrected and amplified the chapter on Geology". As it is, there are no illustrations of any kind in the volume, although the object of the author in his chapter of fourteen pages on the "Geological Formation" is to note the relations of the rocks to the landscape and the flora.

The limestone, described under the name of Colonsay limestone, appears to form part of the Torridonian Series, resting on flags and being overlain by phyllites, and in places by the granitic rock of Scalasaig. The author describes the various types of rock and their economic uses, and notes that the so-called "Scalasaig granite" is a diorite.

The occurrence of boulder-clay in hollows in various localities is mentioned, and the effects of glaciation are noted in the rounded outlines and smoothed and striated surfaces of the rock-formations. In comparing the rocks and flora the author observes that there is more in common between the floras of Colonsay and those of the schistose and gneissose islands of the Outer Hebrides than there is between the Colonsay plants and those of the basaltic islands of the Inner Hebrides. Nevertheless, the soils on Colonsay are naturally influenced by the erratic materials of the Boulder-clay and by the Raised Beach deposits.

The work cannot fail to be a useful guide to the visitor who is interested in Natural History, as may be judged from the title which we give in full.

VI.—Man as an Instrument of Research. Presidential Address of G. W. Lamplugh, F.R.S., to the Hertfordshire Natural History Society, April 12, 1910.

One would hardly accuse Mr. Lamplugh of being a wag; yet the instrument that comes to one's mind more often than any other when dealing with scientific men is connected with boring. For most scientific men are so wrapped up in their little subject that the great world and its issues are lost sight of. We are grateful to Mr. Lamplugh for one sentence—"Everyone who has tried to translate his observations into accurate description must have felt the inadequacy of language." It is a commonplace, but so true! He has, again, touched up those who, having large collections of material or fact, remain mute and neither use them nor allow others to use them to their full advantage. We disagree with him when he advises people to "record simple facts alone, without attempting to demonstrate their intricate relationships or to trouble himself with the technicalities by which these relationships are conventionally expressed". There

[1] Quart. Journ. Geol. Soc., lxiv, p. 298.

is far too much slipshod stuff published now, and a word with a more experienced friend or with an intelligent editor would bring much of this sloppy, half-baked material into line with more mature writing, and render comparison and correlation much easier. The author does not deal with the somewhat threadbare subject of "the pursuit of knowledge for its own sake", which may be a purely selfish proceeding. At the present day it is more generally recognized that work of all kinds should be for the benefit of the community, and that the highest forms of research, like those of Pasteur and Koch, are such as are calculated to ameliorate the sufferings of humanity.

VII.—Brief Notices.

1. Fossil Insects.—Dr. Anton Handlirsch, who has so elaborately worked out the history of fossil insects, is now actively at work describing the various new forms discovered in the rocks. We have before us a collection of his recent papers, and call attention to the following. "Ueber die fossilen Insekten aus dem mittleren Oberkarbon des Königreiches Sachsen" (*Mitth. Geol. Ges. Wien*, 1909, ii). These consist of Blattoid wings, and include a new genus, *Apophthegma*. Another Blattoid, *Pedinoblatta*, n.g., from the Franken Trias, appears in *Abh. Nat. Ges. Nürnburg*, 1910, xviii, the wing being carefully drawn and figured; while yet a third protorthopteron, *Chalcorychus Walchiæ*, is described in the author's "Ein neues fossiles Insekt aus den permischen Kupferschiefern der Kargala-Steppe (Orenburg)" (*Mitth. Geol. Ges. Wien*, 1909, ii).

Dr. Handlirsch discusses the "frühjurassischer Copeognathen und Coniopterygiden" and "das Schicksal der Archipsylliden" in the *Zoologischen Anzeiger*, 1909, xxxv, and in the number of the same publication for May 10, 1910, gives a brief note—"Ueber die Phylogenie und Klassifikation der Mecopteren." A full report of his lecture "Ueber Relikten" will be found in the *Verh. k.k. zool.-botan. Ges. Wien*, 1909, a lecture which dealt with many other forms besides insects; and a criticism of M. Fernand Meunier and his work on fossil insects, privately printed in 1906, may be lost sight of if not mentioned in these pages.

2. Catalogue of Photographs of Geological Subjects, prepared by the Geological Survey and Museum. 8vo; pp. 35. London, 1910. Price 6*d*.—During the past six years the Geological Survey has taken photographs of objects of geological interest in the areas of England and Wales that were being re-surveyed on the 6 inch maps. In Scotland photographic work was commenced by the Geological Survey in 1890, and a catalogue of the photographs preserved in the Edinburgh Office is promised. In the present pamphlet 800 subjects are recorded, and they relate mostly to Cornwall, Devon, Pembroke, and Carmarthen. They include quarry sections, tors, raised beaches, stream-tin works, dykes, pillow-lavas, sand-dunes, crush-breccia, china-clay works, cleavage, contorted strata, etc. It is noted by the Director, Dr. Teall, that negatives, prints, lantern slides, or bromide

enlargements can be obtained of any of the photographs on application being made at the Geological Survey Office in Jermyn Street, where prints may be seen.

3. Annual Report of the Iowa Geological Survey, vol. xix, for 1908, dated 1909.—This volume contains a full report on the coal deposits of the State by Mr. Henry Hinds, and a history of the coal-mining, which dates back to about 1840, by Mr. J. H. Lees. The peat deposits of Iowa are described by Mr. S. W. Beyer. Analyses of both coals and peat, also bibliographies of these subjects, are given.

4. The Quality of Surface Waters in the United States.—This important subject is dealt with by Mr. Dole (Water Supply Paper, No. 236, of the U.S. Geol. Survey, 1909) in a work of which part i contains the results of over 5000 mineral analyses of water from the principal rivers of the United States east of the Rocky Mountains. Daily samples of water from nearly 200 stations were collected for a year, united in sets of ten consecutive samples from the same stream and station, and the composite was then subjected to analysis. The analyses, giving as they do the average composition of the waters, the fluctuations of composition from day to day, and information regarding change of water-level wherever available, form the most complete collection of data regarding the quality of American rivers that has ever been published. They are on this account particularly valuable to railroad engineers and to managers of industrial plants and waterworks.

REPORTS AND PROCEEDINGS.

Geological Society of London.

May 25, 1910.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The Address which it is proposed to submit to His Majesty the King, on behalf of the President, Council, and Fellows, was read as follows, and the terms thereof were approved:—

"To the KING'S MOST EXCELLENT MAJESTY.

"May it please Your Majesty,

"We, Your Majesty's most dutiful and loyal subjects, the President, Council, and Fellows of the Geological Society of London, humbly beg leave to offer to Your Majesty our deepest and most heartfelt sympathy in the great and sudden sorrow which has fallen upon you, and most respectfully to express the grief that we, in common with all Your Majesty's subjects, feel at the great loss which has afflicted the Nation and the Empire in the tragic death of our late beloved and revered Sovereign King Edward VII, in the full vigour of his services for the welfare of humanity and the peace of the world.

"In the depth of our sorrow we find comfort in the assurance that the sceptre of our wise King passes into the hands of one who will keep ever before him the high destiny of the Nation, and we venture humbly to offer our fervent congratulations to Your Majesty on your accession to the Throne, which, under the sway of your ancestors, has become the greatest in the world.

"We trust that the knowledge of the mineral structure of the earth, for a century the special care of this Society, may continue to grow and flourish under the rule of Your Majesty as it has done under that of your illustrious predecessors.

"That Your Majesty's reign may be a long one and that it may overpass in lustre even those of the great Kings and Queens that have preceded you, is the earnest prayer of your devoted subjects."

The President then read the draft of a circular letter regarding the enhanced price of the Geological Survey Maps, which is to be sent to all institutions in the United Kingdom that are likely to be interested in the matter, bespeaking their support for a respectful representation to the Lords of H.M. Treasury. A draft of the terms in which this representation is to be made was also read.

The following communications were read:—

1. "Dedolomitization in the Marble of Port Shepstone (Natal)." By F. H. Hatch, Ph.D., M.Inst.C.E., F.G.S., and R. H. Rastall, M.A., F.G.S.

The Port Shepstone marble is shown by chemical analysis to be a dolomite (the molecular ratio of calcium carbonate to magnesium carbonate being as 3 : 2). It owes its marmorization to thermal metamorphism by an extensive intrusion of granite, which completely surrounds it and penetrates it in broad dykes. This instrusion took place at some time prior to the deposition of the Table Mountain or Waterberg Sandstone, and is therefore pre-Devonian. The dolomite is relegated to the Swaziland Period.

The metamorphism of the dolomite under normal conditions is shown to have produced a saccharoidal marble of coarse texture, consisting almost entirely of carbonates; and the fact that neither periclase nor brucite has been produced in the normal marble is taken to indicate that the high-pressure conditions obtaining during the metamorphism precluded dedolomitization. In those places, however, where the dolomite contains blocks or boulders of earlier granitic rocks, interaction took place between the magnesium and calcium carbonates of the dolomite and the silica and alumina provided by the inclusions, resulting in the production, in the zone of marble immediately surrounding the inclusions, of a number of interesting silicates of magnesium, calcium, and aluminium, such as olivine, forsterite, diopside, wollastonite, and phlogopite, as well as the oxides brucite and spinel. Magnesian compounds predominate, the excess of lime recrystallizing as calcite. A noteworthy feature is the absence of minerals such as garnet and cordierite, which are especially characteristic of low temperature metamorphism, thus indicating the prevalence of a high temperature during the metamorphism of the dolomite.

The paper concludes with a reference to the occurrence of granite boulders as foreign inclusions in other limestones, and a discussion of the chemical reactions by which the formation of the above-mentioned minerals may be theoretically explained as a result of dedolomitization. Comparison is made with the dedolomitized Cambrian limestones of Assynt and Skye described by Dr. Teall and Mr. Harker, from which the Port Shepstone occurrence differs in the localization of the affected areas to reaction rims around foreign boulders, and in the part played by alumina in the formation of new minerals.

2. "Recumbent Folds in the Highland Schists."[1] By Edward Battersby Bailey, B.A., F.G.S.

A description is presented of the stratigraphy and structure of a considerable portion of the Inverness-shire and Argyllshire Highlands. The district considered lies south-east of Loch Linnhe, and extends from the River Spean in the north to Loch Creran in the south.

The following conclusions are arrived at:—

(1) The schists of the district are disposed in a succession of recumbent folds of enormous amplitude—proved in one case to be more than 12 miles in extent.

(2) The limbs of these recumbent folds are frequently replaced by fold-faults, or 'slips', which have given freedom of development to the folds themselves.

(3) The slipping referred to is not confined to the lower limbs of recumbent anticlines, and is therefore due to something more than mere overthrusting. It is a complex accommodation-phenomenon, of a type peculiar perhaps to the interior portions of folded mountain chains. In fact, the cores of some of the recumbent folds have been squeezed forward so that they have virtually reacted as intrusive masses.

(4) In the growth of these structures many of the earlier formed cores and slips have suffered extensive secondary corrugation of isoclinal type.

The Secretary read the following extracts from a letter received from Mr. C. T. Clough, who was unable to be present at the meeting:—

"I think that special attention may be called to the similarity of the effects produced on all the beds in the attenuated limbs of the slip-folds; the hard massive quartzites, for instance, are not on the average any better preserved than the Leven Schists. This seems contrary to what we should expect *a priori*, and it is contrary also to what we find in some areas affected by the post-Cambrian thrusts of the North-West Highlands. For instance, near Ord in the Isle of Skye, just under the western limb of the folded Sgiath-bheinn an Vird thrust the Fucoid Shales become thinner as the thrust is approached, and are ultimately almost entirely squeezed away from between the Pipe-Rock on the one side and the Serpulite Grit on the other.

"It is interesting to consider what may be the relations in age between the slips described by the author and the Moine thrust. The Moine Schists had certainly been folded intensely, and were much in the same condition as they are now, before the actual snap of the thrust took place. The slips of the Ballachulish district seem much more closely connected with the folding. This difference suggests the question whether, in the Moine Schists a little east of the Moine district, slips of the Ballachulish type may not also occur. It is certainly the case that the beds in the opposite limbs of some of the folds east of the Moine thrust show a marked want of correspondence. The differences have hitherto generally been explained by the supposition that the folds concerned were of unusually great depth, so that they brought into proximity beds which originally were widely separated and were formed under different conditions of sedimentation. It seems very possible, however, that the differences may in some cases be due to the presence of slips accompanying the folds. If such slips do occur not far east of the Moine thrust, as is thus suggested, we may be tolerably certain that they are somewhat older than it.

"In conclusion, I should like to express my high appreciation of the perseverance and enthusiasm with which the author has carried out these investigations. I feel confident that his general conclusions may be accepted as correct, and that they mark a great advance in the study of the tectonics of the Scottish Highlands."

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

CORRESPONDENCE.

THE IGNEOUS ROCKS OF THE NORTHERN END OF THE RED SEA.

Sir,—During the year 1909 I paid two visits to the north end of the Red Sea. During these visits I made a careful examination of the igneous rock-masses forming a large portion of the Island of Shadwan and the hill ranges of Jebel Esh, Jebel Um Dirra, and Jebel Zeit on the mainland. It is my intention to describe these rocks in a future paper, and to deal with their relations to one another. The rocks consist chiefly of soda-granites, quartz-felsites, diorites, and intrusive dolerites. The granites are occasionally gneissose, and in such case they are usually accompanied by schists, as on the Island of Shadwan. At other times they merge into the most perfect granophyres of a very acid nature. The relations of these rocks to one another, and to the overlying sedimentary rocks, present problems of more than ordinary interest in the study of the geology of this part of Egypt.

Arthur Wade.

Imperial College of Science and Technology,
Royal College of Science, S. Kensington, S.W.
June 8, 1910.

THE PITFALLS FOR ELEPHANTS IN AFRICA: IN REFERENCE TO DEWLISH.

Sir,—It will be remembered that the Rev. Osmond Fisher, F.G.S., at the Geological Society in 1904 [1] read an interesting paper on the possibility of the remains of *E. meridionalis* found at Dewlish having been snared in a pitfall. Apropos of the narrowness of the trench Mr. A. B. Lloyd has some remarks which may possibly be of interest in connexion with the subject.[2] "On 15th [July, 1903] I . . . camped at Kajura, and at this place had my first adventure . . . My nose in the air and my ears set to catch the slightest sound, while I strained every muscle to push myself forward through the thicket, when there was a sudden airy feeling underneath, and the next moment I found myself jammed hard and fast in a regular death-trap set for antelope. It was a pit about 2 feet wide at the top but narrowing at the bottom to a few inches, the total depth being over 10 feet . . . These holes are dug by the natives in all the game country, and the mouth of the pit is usually very skilfully covered over with a layer of thin twigs and grass . . . I have seen them specially made for elephant."

R. Ashington Bullen.

Hilden Manor, Tonbridge.
June 17, 1910.

[1] Q.J.G.S., February, 1905, vol. lxi, p. 38.
[2] A. B. Lloyd, *Uganda to Khartoum*, pp. 96, 97, 98.

THE TERM 'LATERITE'.

Sir,—The question as to the use of the term 'laterite' raised by me in the September number of last year's Geological Magazine has figured in so many subsequent numbers that I feel some diffidence in asking you to publish any further remarks on the subject. I am indebted to Dr. Evans for an expression of his views, based as they are, I note, on an intimate acquaintance with the material to which the name was first given. There is a tone of remonstrance in Dr. Evans' letter that may appear justifiable under the circumstances, but I venture to think that this has led the writer a little astray from the path of argument and to lose sight of the main issue, which is the practicability at the present day of forcing a new definition of laterite on geologists and engineers, or, indeed, the right of anyone to do so. Dr. Evans is more concerned on account of my opinion that the term is of little use as matters stand now, and falls into the error of crediting me with the statement that it "must be abandoned". For my part, if I treat some of the points raised very briefly, I trust it will be clear that I do so only in order to save your space.

In Dr. Evans' third and fourth paragraphs I cannot see that a strong case is developed against calling highly aluminous laterite 'bauxite', and would refer to the quotations in my last letter, which appear to have been passed over. Dr. Evans is doubtless aware that in *Mineral Industry* some Indian laterites have been referred to as bauxites. Perhaps 'aluminous laterite' as opposed to 'ferruginous laterite' would be more acceptable? My point is that the term 'laterite' alone should not be held to imply the presence of free aluminium hydroxides in quantity, because that was not the original significance of the term, and because that is not implied by the chief users of the term at the present day.

In paragraph 5 Dr. Evans asks what could be more suitable for this well-characterized formation than the name Buchanan applied to it over a century ago. What indeed? But why attach to the name Buchanan gave a new definition that has no etymological connexion with it?

With regard to Dr. Evans' eighth and final paragraph, I cordially agree with him that the application of the rule of priority is needed here, but I cannot agree with him when he says that the term 'laterite' has continued in use with the same significance ever since 1807. It is surprising that the derivation of the word should be so completely ignored by those who make this statement.

It will be remembered that this correspondence commenced because a reviewer stated that only products of weathering containing free aluminium hydroxides in hot, moist climates should be considered as laterite. The presence of these hydroxides in Indian laterites became generally known in 1903, but prior to that year the name had spread to other countries, where it was used, not always in strict accordance with Buchanan's definition, for ferruginous weathering products that are useful in public works. No one denies the great interest of the discovery that Indian and other laterites contain free aluminium hydroxides, but it is questionable whether that gives anyone the right to insist on their presence being considered the leading characteristic of a product whose name indicates its resemblance to bricks.

That the letters I have written may not be said to be wholly critical, may I add that I have lately examined a number of Malayan rocks with a view to determining the presence or otherwise of free aluminium hydroxides, and have not yet failed to obtain a positive result; but the work has been preliminary only, and I am not prepared to make definite statements as to the quantities present or the degree of hydration. A weathered granitic rock gave over 10 per cent. of alumina. A mass of kaolin afforded about 2 per cent. alumina. All the Malayan 'laterites' that I have examined yield a small quantity. The Malacca laterite, which is the only laterite in the Peninsula that I know of agreeing strictly with Buchanan's definition, contains these hydroxides also. A grey clay-slate taken from the top of a pass far from granite outcrops and associated with quartzite yielded a precipitate of aluminium hydroxide equivalent to about ·05 per cent. of alumina.

I do not think for a moment that I am alone in supposing that the production of free aluminium hydroxides is widespread in the tropics, or that it is not confined to laterite in its widest sense; but what would be of great interest is a comparison along these lines of rocks in tropical and temperate regions, for it is hard to believe that the amount of hydroxides found in the tropics is other than a development of a process regulated by temperature, moisture, and perhaps vegetation, and that they are not being produced in smaller quantities in temperate climes also.

J. B. Scrivenor.

Batu Gajah,
Federated Malay States.
May 7, 1910.

OBITUARY.

ROBERT PARR WHITFIELD.

Born May 27, 1828. Died April 6, 1910.

R. P. Whitfield, who was born in New Hartford, New York, had for fifty-four years been engaged in geological and palæontological work. He was one of James Hall's assistants in the first State geological survey of Iowa, from 1856 to 1876; and he then became palæontologist to Professor T. C. Chamberlin's State survey of Wisconsin. He laboured also for Clarence King in the Geological Survey of the Fortieth Parallel, contributing to the Palæontological Reports published in 1877. His researches were mainly on the fossils of the Palæozoic formations, and he dealt with all groups of Invertebrata. From 1872 to 1878 he was Professor of Geology at the Rensselaer Polytechnic Institute, Troy, N.Y., and since 1877 he had been Curator of the Geological Department in the American Museum of Natural History.[1]

[1] For most of the above particulars we are indebted to Mr. G. P. Merrill's *Contributions to the History of American Geology*, 1906.

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AUGUST, 1910.

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THE

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No. VIII.—AUGUST, 1910.

ORIGINAL ARTICLES.

I.—The Augen Gneiss and Moine Sediments of Ross-shire.

By C. T. Clough, M.A., C. B. Crampton, M.B., C.M., and J. S. Flett, M.A., D.Sc.

(WITH A TEXT-MAP.)

Communicated by permission of the Director of the Geological Survey.

IN the centre of Ross-shire, to the west and north-west of Ben Wyvis, there are large intrusive masses of granite gneiss lying in the midst of the sedimentary Moine schists. They have a N.N.E. strike and extend over a tract of country about 20 miles in length, from Loch Luichart, near Garve Station (Dingwall and Skye line), to Carn Bhren, within 3½ miles of Ardgay Station (Inverness and Wick line). A coarse augen gneiss with large elliptical eyes of pink orthoclase or perthite, sometimes 2 inches long, is the principal rock, but a finer-grained granite gneiss also occupies considerable areas, especially in the region of Carn Chuinneag (see Map, Fig. 1). Boulders of the augen gneiss have been widely distributed by ice, and are common on the shores of the Moray Firth, etc. For that reason the "Inchbae augen gneiss" has long been familiar to geologists, though little was known about the parent mass, except that gneisses of this type were exposed on the high road between Garve and Ullapool, particularly in the lower part of Strath Rannoch.

Since 1900 the work of the Geological Survey has proved this augen gneiss to be one of a number of foliated intrusions, perhaps originally all parts or offshoots of a single laccolitic mass, surrounded by an aureole of hornfelses in which the Moine sediments are intensely contact-altered, and have in large measure escaped the subsequent dynamic metamorphism which has elsewhere over a vast area converted them into the great series of schists and gneisses that are generally known as the Moine Series. Elsewhere in all their extent from the north coast of Sutherland to the Ross of Mull these Moine rocks are paraschists and paragneisses, generally of highly metamorphic types, but in this aureole they retain their original bedding and clastic structures in singular perfection. It has been proved that when the Moine sediments were invaded by the granitic rocks of this region they were sandstones and shales of quite normal character; and much light has been thrown on the history of the district and the manner in which both igneous and sedimentary rocks acquired their metamorphic structures. The one-inch map of this country (sheet 93) is now in preparation, and is to be accompanied by a memoir in which the facts will be stated in some detail, but we propose to give a brief summary of the principal results with an outline of the evidence, believing that the conclusions are of general interest to geologists.

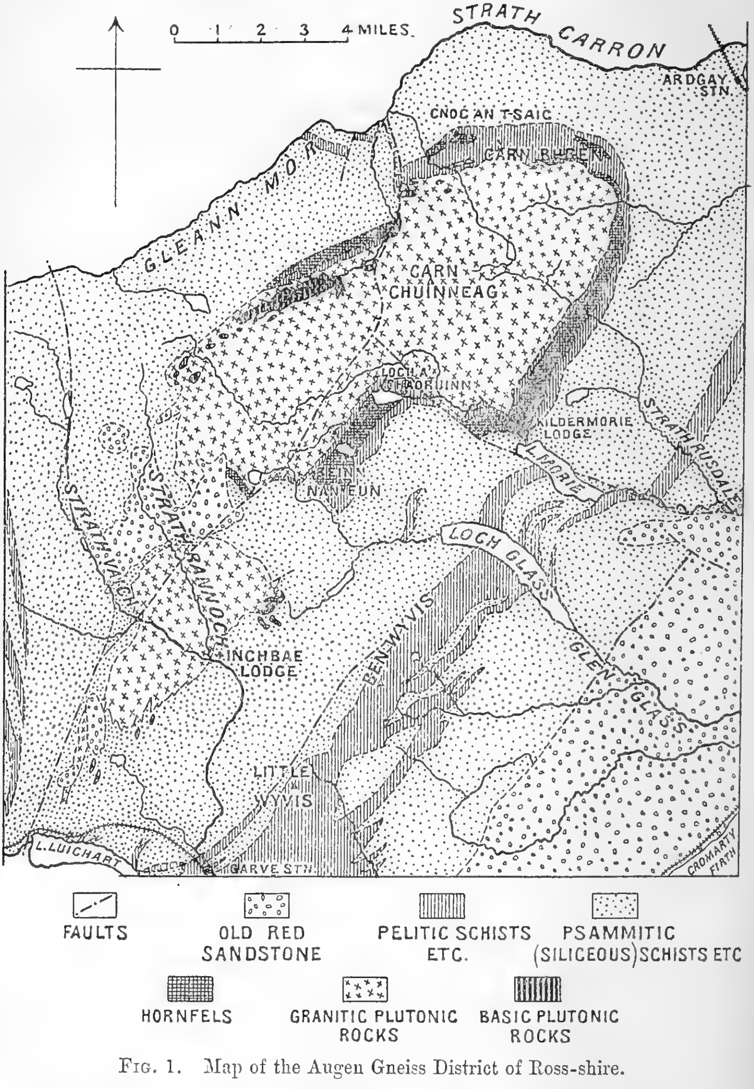


Fig. 1. Map of the Augen Gneiss District of Ross-shire.

The relations of the chief masses of plutonic rock are indicated in the accompanying map (Fig. 1). It will be seen that the Inchbae outcrop of granite gneiss is about $5\frac{1}{2}$ miles long and 3 broad.

Separated from the N.N.E. end of it by a space of $1\frac{1}{4}$ miles, most of which is occupied by Old Red Sandstone of later age than the granite, is the much more extensive plutonic mass of Carn Chuinneag, 12 miles long and 4 or 5 miles broad, which includes a considerable variety of orthogneisses. On the south-west side of the Inchbae mass a group of smaller detached outcrops of augen gneiss extend several miles in a south-west direction as far as Loch Luichart, and are represented also on the west side of a big fault, striking N.N.E. on the west side of this loch.

That the augen gneiss was once a porphyritic granite is proved in several ways. In some places the large phenocrysts of orthoclase preserve their original idiomorphic outlines and are surrounded by a granitic matrix, in which the original grains of quartz have not suffered granulitization. The surrounding hornfelses are invaded by tongues and veins of granite which have undergone very little deformation. At the junctions in some places, as at Kildermorie Lodge on the south-east side of Carn Chuinneag, the margin of the granite is filled with immense numbers of angular inclusions of baked sediment (garnetiferous biotite hornfels, etc.). Moreover, as already stated, there is an aureole in which certain sediments, elsewhere represented by the Moine schists, have the composition and structure of hornfelses derived from impure sandstones and arenaceous shales.

Within the intrusions various types of plutonic rock may be found. Towards the north-west margin of the Carn Chuinneag mass there are some outcrops of dark-green basic rocks, which have been proved to be gabbros (without olivine) and augite diorites. Others are quartz diorites, and there are also more acid types which correspond to tonalites and hornblende granites.

In some places the basic rocks, like the porphyritic granite, are nearly free from foliation, and show their original structures fairly well preserved; elsewhere all these rocks have been converted by movement after consolidation into amphibolites, hornblende schists and hornblende gneisses. The basic rocks occur in relatively small amount, and are entirely in the form of inclusions, large or small, surrounded and veined by the granite. The field evidence proves that they are earlier than the granite, and it is probable that they originated by the differentiation of an acid magma in much the same way as the basic rocks of Garabal Hill and of so many other intrusions of the Newer Granite Series in the Scottish Highlands and the Southern Uplands.

Towards the centre of the Carn Chuinneag mass there are several areas of ægirine riebeckite gneiss, a rock extremely rich in alkali felspars, with quartz and soda-pyroxenes and amphiboles. We may mention also the remarkable occurrence of masses of magnetite and cassiterite (containing sometimes nearly 16 per cent. of tinstone) on the north-west shoulder of Carn Chuinneag; these are accompanied by a peculiar dark biotite gneiss with large rounded garnets and much albite. This mineral paragenesis is almost unique, and the origin of this ore-deposit is a problem very difficult of solution. The finer-grained granite gneiss of Carn Chuinneag, in which the ægirine riebeckite gneiss and the albite gneiss occur, is a biotite gneiss. Other fine-grained gneisses, which contain muscovite but little or no biotite, probably represent foliated aplites.

The history of the foliation in the orthogneisses is intimately connected with the history of the foliation in the schists, but in the former there is very complete proof that this structure was developed after the igneous rocks were quite solid. Although sometimes nearly normal granites, gabbros, etc., they generally show some indication of deformation. In the porphyritic types the phenocrysts of quartz and felspar are usually less sheared than the matrix, which must consequently have been solid before the rock was crushed. The quartz breaks down more readily than the felspar, and every stage of granulitization can be made out. Where a plexus of acid veins permeates the basic rocks, the latter, though older, are never in a different state from the granites, that is to say, there is no evidence that the basic rocks were foliated before the granite invaded them (as is often seen in the Lizard district). Sometimes a complex of this sort has been pulled or rolled out into a banded gneiss, not unlike some types of the Lewisian, but both acid and basic rocks are in the same state, and the derivation of such a gneiss from an intrusion breccia can be followed step by step in the field. The crushing and consequent development of foliation vary considerably in intensity from point to point, and sometimes suddenly along certain lines of thrust or special shearing, which frequently strike N.N.W. But for the most part the foliation maintains the N.N.E. trend, which is characteristic of the Moine schists of this area also, and often strikes across the boundary with the schists. Another fact of especial significance is that the big masses of granite, and also the thin veins in the paraschists, are in a number of places foliated across their length, with the same foliation as marks the rocks around them.[1]

The sedimentary schists that form the country rock are arranged in a fold with its major axis striking N.N.E., nearly parallel to the lengths of the granite masses, and away from the augen gneiss they differ in no respect from Moine schists and gneisses in other parts of Scotland. We may distinguish two main types—(1) the siliceous or psammitic schists and gneisses, with both muscovite and biotite, (2) coarse pelitic or semipelitic garnetiferous mica schists. Thin bands of zoisite-hornblende gneiss and of granulite with prisms of zoisite nearly an inch long are also found. The whole of these schists, as is well known, were originally sedimentary rocks (arkoses, shales, marls and sandstones), and with them occur dark hornblende chlorite schists which represent basic igneous masses in a state of complete metamorphism. In these rocks the traces of original clastic or igneous structures have often been effaced, though relics of pebbles of quartz and felspar in the psammitic gneisses locally betray their sedimentary origin; the quartz pebbles are often dragged out into long ribbons. There are moreover in these Moine rocks no minerals of thermal origin

[1] This was first made out by Dr. B. N. Peach at the edges of the Loch Luichart outcrops, and was mentioned by him in the *Summary of Progress of the Geological Survey* for 1898, p. 9.

(such as andalusite) and no hornfels structures. Recrystallization and the development of foliation have converted them into schists and gneisses, typical products of regional metamorphism.

But in certain areas around the edge of the granite, in a strip of country that varies in width up to about a mile, quite other types of rock are found. Many of them are fine-grained, flinty-looking, with a well-marked banding due to bedding. From the abundance of black mica in very small plates these rocks have a bluish leaden colour. They are hard and splintery, breaking in any direction, and sometimes contain rounded garnets as large as peas, or prisms of andalusite half an inch in length. When first they were encountered these rocks were recognized by Dr. Peach as hornfelses, typical thermo-metamorphic products of the action of the granite intrusion on sandy shales. Nothing like them had been previously seen in any part of the Moine country.

In the rocks of the Southern Highlands, however, various instances are known where hornfelses retain in exceptional perfection the original characters of sedimentary rocks. On the north-west of the Ben Vuroch augen gneiss (a foliated granite by no means unlike that of Carn Chuinneag) Mr. Barrow had previously detected pyroxene hornfelses (calc-flintas), fine-grained, with bedding preserved. Near Loch Awe and in Knapdale and Islay thin bands of hornfels have been frequently observed at the margins of epidiorites that were once intrusive dolerites.

The minerals of the banded hornfelses are quartz, felspar and brown mica. Very generally they contain garnet, and sillimanite also is common as small prisms densely clustered. Pseudomorphs of andalusite are found only along certain bands, sometimes in the form of typical chiastolite with the black cross-shaped markings, sometimes in large eumorphic prisms; but the mineral is always replaced by white mica and kyanite. Pseudomorphs after cordierite have been seen in one or two rocks, and there are also compact pyroxene hornfelses derived from the marl-bands (calcareous shales) that give rise to the zoisite hornblende granulites under other conditions. The fine biotite hornfels is often 'spotted' with small spots, exactly in the same manner as a spotted slate from the aureole of a Cornish granite.

The banding of the hornfels is due to the alternation of laminæ rich in quartz with others more rich in biotite. The quartzose bands often contain minute pebbles of rounded quartz; sometimes they have the structure of argillaceous sandstones, well preserved in every detail. On the surfaces of certain layers there are markings strongly suggestive of sun-cracks and ripple-marks, and others which may possibly represent worm-tubes. The banding is evidently due to bedding, and the rocks were originally fine laminated arenaceous shales. This has been confirmed also by chemical analyses. Where the contact alteration is most intense or the rock has been very argillaceous the clastic structures, as might be expected, are less obvious, but they are never absent.

It is to be noted that in the least sheared hornfels the bedding is generally lying at gentle angles, and over wide areas near Kildermorie and south of Loch Chaoruinn it is dipping at right angles to the general direction of the bedding and foliation in the neighbouring schists. In the Loch Chaoruinn district the rocks are further arranged in the form of a syncline, traceable by means of one of the andalusite bands mentioned above. This syncline is truncated on the one hand by the granite margin and on the other by the schistose rocks. The pelitic mass in the areas just referred to is in the condition of hornfels, except along a narrow belt in contact with the granite, and at its outer margin next the psammitic schists, in both of which positions it has generally undergone considerable shearing. The pelitic outcrop, which originally must have been a single mass of shale or sandy shale, is now at some points an unsheared hornfels, while at others it has been converted into a garnetiferous mica schist, with folds and foliation striking at right angles to the bedding in the hornfels.

As we proceed outward from their centres the masses of hornfels in other areas also can usually be traced passing into mica schist, whether we move towards the granite or away from it. There are many intermediate stages between typical hornfels and typical mica schist, one of the best marked being a fine greyish rock full of small micas, white and black. This may be called the stippled schist, and often forms a belt next to the granite. It has more mica than the hornfels, especially muscovite, which has developed at the expense of felspar. The garnets of the hornfels persist, but the sillimanite and andalusite disappear. The latter passes first into kyanite, and pseudomorphs of kyanite after chiastolite, retaining the original outlines and structure, though consisting only of aggregates of small divergent prisms, may often be seen. These we take to be illustrations of the efficiency of pressure in substituting that form of the silicate of alumina which has the highest specific gravity and least molecular volume. Later the andalusite crystals are greatly bent and puckered and converted into white mica, the large prisms being then drawn out into pale films that lie along the cleavage.

The stippled schists are fissile, as their micas have a parallel orientation that is lacking in the hornfels. This is a new structure, namely, foliation. The direction of orientation often crosses the bedding, and as the foliation develops the sedimentary banding gets less evident, though still persisting. The rocks are being sheared and interstitial movement is taking place; the dragging out of the andalusite proves this and also the deformation of the quartz pebbles. In the other schists, which are more coarsely crystallized than the stippled schists, the mica plates get longer and larger; felspar vanishes almost completely, though sometimes a little albite makes its appearance. The ultimate product is a mica schist with each plate of mica a hundred to a thousand times larger than those of the hornfels. We note the operation of three processes closely connected—(1) interstitial movement, (2) recrystallization with orientation of the micas perpendicular to the directions of stress or along the planes of movement, (3) continued growth in size of the characteristic minerals of the schist. Here again chemical analyses have proved that the coarse mica schist was originally the same rock as the fine blue splintery hornfels. It is probable, however, that the extreme outer margin of the pelitic band near Kildermorie never was in the condition of hornfels, but was converted directly into mica schist.

The unsheared hornfels is never found more than a mile from the granite margin. Round the granite the 'aureole' is not continuous, but is broken at certain places by the intervention of shearing. It should also be stated that at the south-west margin of the Carn Chuinneag mass and around most of the Inchbae mass the granite is in contact with psammitic schists, in which little evidence of contact alteration has been detected.

In the Moine rocks, at a distance of a mile or more from the granite, there is great uniformity in the character of the foliation. The explanation that suggests itself is that these sediments were soft and readily yielded to folding, while free internal movement gave full play to the forces of recrystallization by which schists are produced. Some parts of the granite mass and many parts of the hornfelsed rocks of the aureole were, on the other hand, more resistant to folding, and considerable blocks of them moved *en masse* and retained their original structures, while in adjacent portions there was much internal shearing, with consequent production of cataclastic structures and development of schistosity.

The hornfels has been sheared decidedly less than the granite, and its original characters are in better preservation. The physical structure of these rocks seems to give them a remarkable cohesion and toughness under the conditions of pressure and folding that occasion metamorphism of the 'regional' type. This is no doubt due to their finely crystalline state, the perfect interlocking of their minerals, which, having grown in a solid mass, often enclose one another; and especially to the development of authigenic new felspar in the interstices between the sand-grains, cementing them together into a very rigid mass. It seems clear, from the facts known, both in Easter Ross, Ben Vuroch, Knapdale, etc. (see p. 341), that fine hornfelses are rocks from which schists are not readily formed.

Mr. Barrow has advanced the hypothesis[1] that the Ben Vuroch hornfelses were preserved because they were sheltered behind a large resistant mass of granite. But at Carn Chuinneag the facts show clearly that the hornfels is a much more resistant rock than the granite; moreover, hornfelses occur on all sides of the granite, not only on the north-west, which was the lee side, but also on the south-east, from which the pressures came.

It is obvious that the sediments and hornfelses were solid when they were sheared and converted into mica schists, and the phenomena observable at the junction of granite and hornfels render it equally clear that the igneous rocks also were thoroughly crystallized before the movements began. If the hornfels at the junction is quite free from foliation—a rare condition—the granite also shows its igneous structures well; but if the hornfels has passed into a mica schist the igneous rock is always gneissose. This is especially noticeable in the fine granite veins that penetrate the schists; they cut the bedding clearly in the banded hornfelses, and in the mica schists they have a foliation that corresponds with that of the schists and often crosses the veins from side to side.

[1] "The Geology of the Country round Blair Atholl, Pitlochry, and Aberfeldy": Mem. Geol. Surv., 1905, p. 93.

Still more convincing evidence, if that were possible, that the schists and gneisses of this country were developed from solid rocks by pressure and movement is furnished by a series of remarkable crush-zones that traverse both igneous and sedimentary rocks alike. Some of these were described by Mr. Clough in 1902,[1] but the main facts may be recapitulated here.

After the movements that produced the main foliation of the district had come to an end, and the rocks were for the most part in the same state as they are at present, a group of basic dykes (olivine dolerites) were injected along a system of fissures that have mainly a N.N.W. trend. Thereafter movements again set in (posthumous movements), but on a lesser scale and more local in their distribution. They folded the previous foliation in the gneisses and schists, and their action appears in a concentrated form along certain crush-zones or belts of secondary shearing, which are narrow strips running in various directions, but often nearly at right angles to the strike of the general folding in the Moine rocks. Where the hornfels is involved in one of these crush-zones it may be changed within a few feet into a lustrous mica schist. When a crush-zone passes from the schists into the granite gneiss, the latter also becomes highly schistose with a large development of new white mica. In the granite gneiss the vertical dolerite dykes were apparently weak rocks that easily yielded to pressure, for secondary shear zones rather commonly take the line of these dykes. In that case the basic rock assumes the form of a typical hornblende schist, rather fine-grained but perfectly foliated and completely metamorphic. The foliation in the crush-zones is parallel to the length of the zone, and consequently is often at right angles to the foliation of the Moine rocks and the granite gneiss. At the edges of the hornblende schist dykes a new foliation makes its appearance in the granite gneiss. Most perfect at the junction with the dyke, it fades away in a few inches. It is evidently a superinduced structure which masks the original foliation of the acid rock, yet it is often very highly developed, and thin slabs may be split off from the gneiss at the edge of the basic dykes with a structure which may be described as mylonitic at a considerable angle to the foliation in the same rock only a couple of feet away.

The fine-grained structure of the dykes proves the granite to have been cold at the time when they were injected, and the development of a new foliation in the gneiss that forms the walls of the dykes proves equally clearly that the main foliation was already developed before these rocks were sheared. When the later movements supervened the granite compressed the dykes as a vice grips a piece of soft iron. The weaker metal gives way and is deformed, but before its rigidity is overcome the jaws of the vice also suffer.

We believe that the granite gneiss and its aureole furnish us with an undoubted example of pure dynamic metamorphism. All the rocks involved—igneous, sedimentary, and the contact-altered hornfelses—were free from foliation when the movements began, and when the movements came to an end they were, in varying degrees of perfection,

[1] *Summary of Progress of the Geological Survey* for 1902, p. 150.

schists and gneisses as we find them now. This implies a similar history for the whole Moine system of the North of Scotland. The age of these rocks and the period or periods of movement that produced the foliation are not satisfactorily established, but that the movements occasioned the metamorphism is sufficiently clear. There may be, and probably are, in the Scottish Highlands orthogneisses that have a different history from the Carn Chuinneag granite gneiss. Mr. Barrow has shown reason to believe that near Blair Atholl some orthogneisses have structures developed in them by pressures acting during consolidation.[1] Similar types of gneiss are believed by Dr. Flett to occur in the Lizard Peninsula. But in the granite gneisses of Ross-shire no structures have been met with that cannot be explained as occasioned by the action of orogenetic pressures on normal igneous rocks completely crystallized.

II.—Note on two Cephalopods [*Pachydiscus farmeryi*, n.sp., and *Heteroceras reussianum* (d'Orbigny)] from the Chalk of Lincolnshire.

By G. C. Crick, Assoc. R.S.M., F.G.S., British Museum (Natural History).[2]

(PLATE XXVII.)

The British Museum collection has lately been enriched by two Cephalopods from the Chalk of Lincolnshire that seem to be worthy of notice; one being a new species of *Pachydiscus* (*P. farmeryi*), the other being referable to the genus *Heteroceras*.

1. Pachydiscus farmeryi, n.sp. (Pl. XXVII, Figs. 1, 2.)

Diagnosis—Shell (internal cast) discoidal, umbilicated; greatest thickness at about two-fifths of the height of the whorl from the suture, about three-tenths of the diameter of the shell; height of the outer whorl about three-eighths of the diameter of the shell. Whorls few, exact number unknown, probably about five; inclusion about one-half; umbilicus not very deep, about two-fifths of the diameter of the shell in width, exposing the inner whorls. Whorl broadly oval in transverse section, a little higher than wide; indented to about a quarter of its height by the preceding whorl; periphery broadly rounded, ill-defined; lateral area rather inflated, not sharply defined from the umbilical zone; umbilical zone convex, imperfectly defined from the lateral area. Body-chamber occupying fully one-half of the outer whorl; aperture not seen. Details of chambers and of suture line imperfectly known. The surface of the outer whorl with about nine curved, raised, obtusely-rounded, forwardly-projected ribs, each being raised on the lateral area into a transversely-elongated node, which, in the course of the outer whorl, passes from the vicinity of the umbilical margin to about the middle of the lateral area, each of the last four or five ribs passing into a longitudinally-flattened tubercle at the margin of the peripheral area; the spaces between these principal ribs occupied, certainly on the peripheral area and

[1] "The Geology of the Country round Blair Atholl, Pitlochry, and Aberfeldy": Mem. Geol. Surv., 1905, pp. 98–100.

[2] Published by permission of the Trustees of the British Museum.

possibly also on part of the lateral area, by five or six finer ribs, which cross the peripheral area in an orad-convex curve; near the anterior end of the outer whorl there is, behind each pair of flattened tubercles at the edge of the periphery, a similar but smaller pair at about two-fifths of the distance between one pair of large tubercles and the next succeeding pair; the inner whorl with large widely-spaced obtusely-rounded nodes.

The holotype (Figs. 1, 2) is a somewhat distorted natural internal cast of rather more than one and a half whorls; the innermost whorls are wanting. The fine ribs are specially visible on the peripheral area of the first and last portions of the outer whorl, but the surface of the specimen is not sufficiently well preserved to show if these were continued over the lateral area. The surface of the fossil generally is too imperfectly preserved to show the course of any of the septal sutures, although septa appear to have been present throughout fully two-thirds of the outer whorl. The specimen, which now forms part of the National Collection [B.M. No. C. 12,220], was collected by J. R. Farmery, Esq., after whom the species is named. Its measurements are: greatest diameter, 91·5 mm. (100); width of umbilicus, 37·5 mm. (41); thickness of outer whorl, 27·5 mm. (30); height of outer whorl, 34·75 mm. (38); ditto above preceding whorl, 23 5 mm. (25·6).

Horizon and Locality.—Turonian, zone of *Holaster planus*: Boswell, near Louth, Lincolnshire.

Affinities and Differences.—The specimen greatly resembles Schlüter's *Ammonites auritocostatus*,[1] but that species, recorded by its author from the *mucronata* beds (Senonian) in Hanover, is more narrowly umbilicated than the English form; the specimen from near Darup, Westphalia, which Schlüter[2] figured and doubtfully referred to this species, but has been named by A. de Grossouvre[3] *Pachydiscus ambiguus*, and recognized by him in the Middle Campanian at Tauillard (Charente), France, is not only more narrowly umbilicated but a more compressed shell, the lateral area lacking transversely-elongated nodes, whilst between each pair of nodes at the margin of the periphery there are two or three fairly-prominent simple ribs extending uninterruptedly from the umbilical margin over the sides and the peripheral area. It is also more widely umbilicated than the example from the neighbourhood of Gan, near Pau (Basses-Pyrénées), that Seunes[4] referred to Schlüter's species, but which Grossouvre[5]

[1] C. Schlüter, *Beitrag zur Kenntniss der jüngsten Ammoneen Norddeutschlands*, 1867, p. 20, pl. iii, fig. 2 (*Ammonites Proteus*, a name preoccupied by d'Orbigny). C. Schlüter, "Cephalopoden der oberen deutschen Kreide," pt. ii: *Palæontographica*, Bd. xxi, Lief. ii, 1872, p. 70, pl. xxii, figs. 4, 5 (not 6, 7 = *Pachydiscus ambiguus*, A. de Grossouvre).

[2] C. Schlüter, "Cephalopoden der oberen deutschen Kreide," pt. ii: *Palæontographica*, Bd. xxi, Lief. ii, 1872, p. 70, pl. xxii, figs. 6, 7.

[3] A. de Grossouvre, *Mém. Carte géol. détaillée de la France: Recherches sur la craie supérieure.*—Pt. ii: *Les Ammonites de la craie supérieure*, 1893, p. 198, pl. xxix, fig. 3.

[4] J. Seunes, *Recherches géologiques sur les terrains sécondaires et l'éocène inférieur de la région sous-pyrénéenne du sud-ouest de la France* (*Basses-Alpes et Landes*), 1890, p. 239, pl. viii, fig. 4.

[5] A. de Grossouvre, op. cit., p. 197.

identifies with *Pachydiscus Sturi* (Redtenbacher)[1] from the so-called Gosau Beds at Muthmannsdorf, Austria, a species which he also records from Mas de Blas Giner, near Alcoy (province of Alicante), Spain; in all cases in the Upper Senonian.

The Lincolnshire specimen, although belonging to this group of forms, is easily distinguished by its wide umbilicus. Occurring at a lower horizon than the other species mentioned, namely, in the zone of *Holaster planus*, one would naturally expect to find a more widely umbilicated form.

2. HETEROCERAS REUSSIANUM (d'Orbigny).[2] (Pl. XXVII, Fig. 3.)

The specimen which seems to be referable to d'Orbigny's genus *Heteroceras* was obtained by the Rev. C. R. Bower from the *Holaster planus*-zone at North Ormsby, Lincolnshire. In this genus there is a turreted portion as in *Turrilites*, but the terminal portion of the shell is bent into the form of a hook. The present specimen (Fig. 3) appears to be a portion of the terminal hook of an example lying upon, and with one end partially imbedded in, a small block of chalk, the portion on the right-hand side being the anterior or apertural end. Close to this end of the hook there is a portion of a whorl of a turreted Cephalopod (marked *a*) that possibly originally belonged to the same specimen as the larger fragment. The hook, which has a total length of about 110 mm. as measured along the median line of its periphery, does not lie quite in one plane, but has a double curvature; this character is exhibited more especially by the posterior portion of the hook that is only partially exposed and is shown on the left-hand side in the accompanying figure, this limb being apparently the one by which the hook was attached to the turreted portion of the shell, and therefore the younger portion of the hook. The transverse section of the last portion of the shell (the part on the right-hand side in the accompanying figure) is a compressed oval, the ventro-dorsal and transverse diameters being 25 and 17 mm. respectively; the cross-section of the other limb cannot be ascertained as it is partially imbedded in matrix, but the greatest width exposed is about 25 mm. The younger portion of the hook, excepting the inner or antisiphonal area, is ornamented with simple, rather oblique, and somewhat irregularly-placed ribs, which pass uninterruptedly over the periphery, where they are about 2 mm. apart; at irregular distances some of these are thicker than the rest and roughened and may originally have been produced into several small spines, but they are now too much abraded to state this with certainty; the later portion of the shell seems to have been ornamented with similar fine ribs, but at irregular intervals some of the ribs are greatly thickened on the outer portion of the lateral area and on the periphery of the whorl. The septa

[1] A. Redtenbacher, "Die Cephalopoden der Gosauschichten": Abh. d. k. k. geol. Reichsanst., Wien, Bd. v, 1873, p. 129, pl. xxx, fig. 10 (*Scaphites Sturi*).

[2] *Hamites reussianus* d'Orbigny, *Prod. de Paléont.*, vol. ii, 1850, p. 216. This species was placed by Pictet and Campiche in the genus *Anisoceras*; by Schlüter in the genus *Heteroceras*; and by Geinitz, Roemer, and Fritsch in the genus *Helicoceras*. For synonymy and references, see H. Woods, Quart. Journ. Geol. Soc., vol. lii, 1896, pp. 74, 75.

cannot be seen; possibly the whole of this fragment was occupied by the body-chamber.

The specimen greatly resembles the large example of *Heteroceras reussianum* (d'Orbigny) from the 'Scaphiten-Pläner' near Oerlinghausen, in the Teutoburger Wald, N.W. Germany, figured by Schlüter,[1] who states (*op. cit.*, p. 109) that this fossil is one of the most characteristic fossils of the 'Scaphiten-Pläner'. Although there are only obscure indications of the periodical spiny ribs such as are represented in Schlüter's figure, the fossil otherwise so closely resembles that figure, that it is here referred to the same species.

From England[2] this species has been recorded from the Chalk Rock (zone of *Holaster planus*) of Bedfordshire (Luton Railway Cutting,[3] and near Dunstable[4]); Hertfordshire (Hitchin;[5] Preston, near Hitchin;[6] Boxmoor, near Hemel Hempstead;[7] and Clothall, south-east of Hitchin[8]); Berkshire[9] (Cuckhamsley[10] and Basildon[11]); Oxfordshire (Aston Hill, near Aston Rowant;[12] and doubtfully from Chinnor Hill[13]); from the zone of *Holaster planus* in Buckinghamshire[14]; from the same zone at Dover[15]; and from the same horizon in Hampshire.[16]

EXPLANATION OF PLATE XXVII.

Pachydiscus farmeryi, G. C. Crick.

FIG. 1. Lateral aspect of the type-specimen; the finer peripheral ribs are shown on the right-hand side of the figure. Turonian, zone of *Holaster planus*: Boswell, near Louth, Lincolnshire. Original in the British Museum (Natural History), register No. C. 12,220. About four-fifths nat. size.

,, 2. Peripheral aspect of the same, showing the pairs of elongated nodes at intervals on the peripheral area; the finer transverse lines between succeeding pairs of nodes are visible in the upper part of the figure. About four-fifths nat. size.

Heteroceras reussianum (d'Orbigny).

,, 3. Small block exhibiting the terminal hook, and (at *a*) the impression of a small portion of the turreted part, of a specimen. Turonian, zone of *Holaster planus*: North Ormsby, Lincolnshire. Original in the British Museum (Natural History), register No. C. 12,118. About two-thirds nat. size.

[1] C. Schlüter, *Palæontographica*, Bd. xxi, Lief. v, 1872, pl. xxxii, fig. 19.

[2] For list of foreign localities, see H. Woods, Quart. Journ. Geol. Soc., vol. lii (1896), p. 75.

[3] H. Woods, op. cit., p. 75. A. J. Jukes-Browne, *Cretaceous Rocks of Britain* (Mem. Geol. Surv.), vol. iii, *The Upper Chalk of England*, 1904, p. 228.

[4] H. Woods, op. cit., p. 75. A. J. Jukes-Browne, op. cit., p. 228.

[5] H. Woods, op. cit., p. 75.

[6] A. J. Jukes-Browne, op. cit., p. 228.

[7] *Ibid.*, p. 228. [8] *Ibid.*, p. 228. [9] *Ibid.*, p. 470.

[10] H. Woods, op. cit., p. 75.

[11] C. P. Chatwin & T. Withers, Proc. Geol. Assoc., vol. xx, pt. v, March, 1908, p. 407.

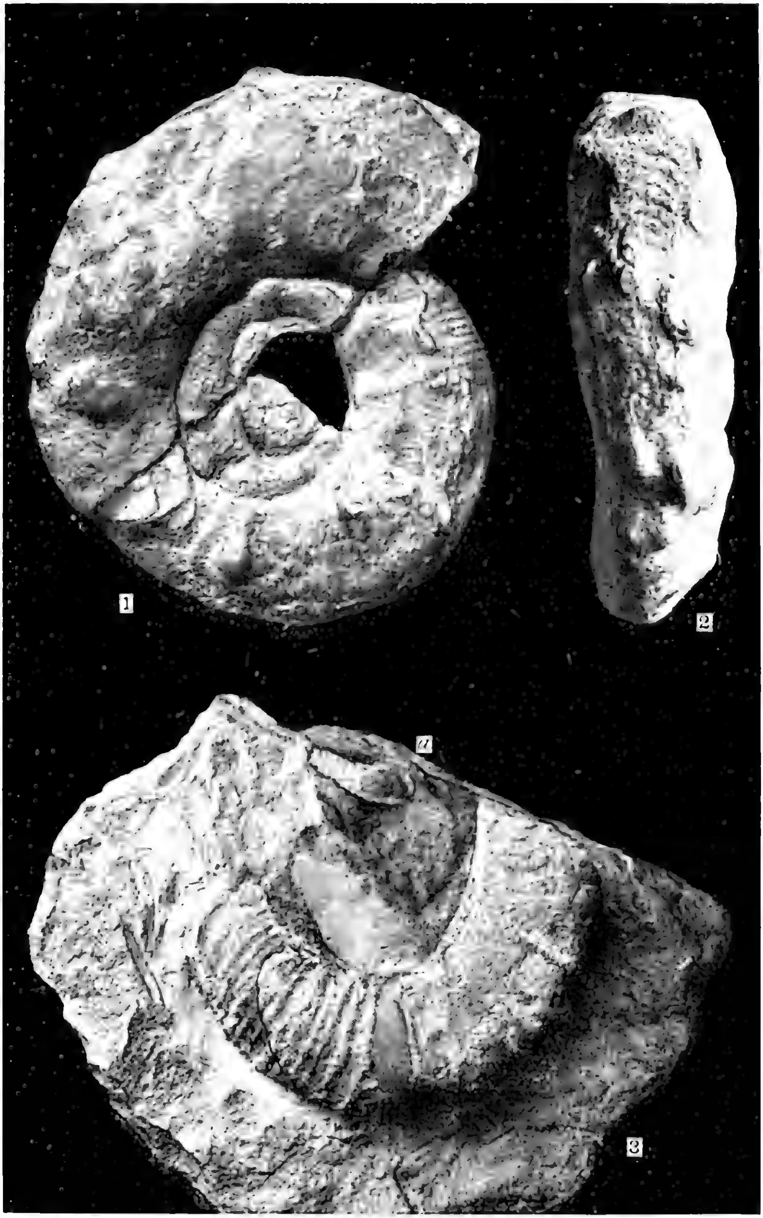
[12] A. J. Jukes-Browne & H. J. Osborne White, *Geology of the Country around Henley-on-Thames*, etc., 1908 (Mem. Geol. Surv. England and Wales, expl. of sheet 254), p. 54.

[13] A. J. Jukes-Browne, op. cit., p. 213.

[14] *Ibid.*, p. 470.

[15] A. W. Rowe, Proc. Geol. Assoc., vol. xvi, pt. vi, February, 1900, p. 366.

[16] A. J. Jukes-Browne, op. cit., p. 65.



Chalk Ammonoids from Lincolnshire.

III.—Some Ambulacral Structures in the Holectypoida.

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

THE phenomena of 'plate-crushing' in the course of the growth of the ambulacra of the regular Echinoids have for many years been utilized for purposes of classification of those forms, but the similar features which exist among some of the irregular types have not been studied in such detail as to render them systematically useful. It is with a view to showing that the structure of the ambulacra in one group of the Echinoidea Irregularia can be relied upon as an index of the relationships of the various genera, that this note has been written. It makes no pretence at completeness, as the material and time available have not been sufficient to allow of an exhaustive study. But the results of those observations that have been made seem to indicate that among the Holectypoida it should be possible, with the aid of zonal collecting, to trace genetic series among the various species, and perhaps to bridge the gulfs existing between the genera, by a study of their ambulacral plating.

That this method could be applied to the Holectypoida only seems certain. Among the Spatangoida the ambulacra are composed throughout of simple primary plates, varying greatly in shape and size, but not complicated by the development of demi-plates, except in the immediate vicinity of the peristome. The petaloid portions of the ambulacra in the Clypeastroida may exhibit the phenomena of 'plate-crushing', but I have only observed demi-plates in one specimen of a *Clypeaster* from the Miocene of Southern Europe. In any case, when the ambulacrum is traced beyond the limit of the petal, it is found to be composed of polygonal primary plates throughout its length.

In the Holectypoida, a group which is regarded as being the order of the Irregularia least removed from the regular type, the complexity of the ambulacral plating is often comparable with that in the simpler forms of the Diademoida. Among the latter group, in the more primitive sub-order of the Diademina, the ambulacrals are united in sets of three to form one compound plate, and a triple arrangement also obtains in the plates of the Holectypoida. But the arrangement of the component parts of a complete ambulacral in such a genus as *Conulus*, although in parts similar in appearance to that which is found in forms allied to *Arbacia*, is arrived at in a strikingly different manner. So regular is the order in which the plates become crushed into demi-plates that it is possible to regard the series of three which ultimately form a compound plate as being made up of three entirely different kinds of plate.

Before the region of crushing is reached there is no visible difference between the members of the simple row of primaries (see Fig. 2, *Pygaster*), but when the modification sets in, these plates succumb with surprising regularity, always in a definite order. It will be convenient for the purpose of this note to designate the individuals of the series of three plates by the letters *a*, *b*, *c* (see Fig. 1). These individual plates bear the following relation to one another: plate *a* will remain a primary throughout the entire ambulacrum, and will, as it were, include the remnants of the others; plate *b* will retain its primary character later than plate *c*, and when both of these plates have become reduced, *b* will be constantly larger than *c*. The compound plate resulting from the maximum of crushing is composed, counting from its adapical suture to its adoral margin, of these three plates in the order *b*, *c*, *a*; *b* and *c* being let in to the adapical portion of *a*. This feature is explained by the diagram, Fig. 1. Irregularities occur at times in this sequence of events, more especially near the peristome, but in those cases of marked departure from the scheme that I have noticed there is always a tendency for the regular order to be resumed as soon as possible. The specimens that conform to this outline scheme are, however, very largely in excess of those which exhibit modifications, and I feel confident in regarding this as the typical ambulacral formation among the Holectypoida.

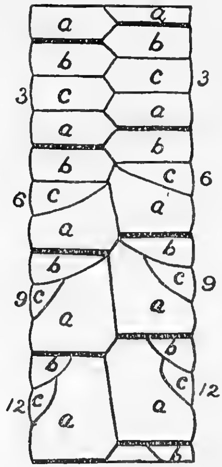


Fig. 1. Generalized diagram illustrating method of plate-crushing in the Holectypoida.

The feature of this 'plate-crushing' which seems to be most valuable for making a study of genetic affinities is that the point at which the demi-plates first appear varies in a constant series. In a suite of twenty specimens of *Conulus albogalerus*, the plate of set *c*, which first becomes modified, was always No. 9 (counting from the latest formed plate of set *a*), both in the five ambulacra of each individual and in the whole series of specimens. This fact seems to show that the position of the first 'crushing-point' may be relied upon as a specific criterion. An examination of several specimens of other species of *Conulus* confirms this belief. Further generalizations must, however, be postponed until a critical examination of certain forms has been undertaken, and the resulting diagram analysed.

The four genera here discussed are *Pygaster*, *Holectypus*, *Discoidea*, and *Conulus*. Species of all of these genera may be found in great abundance at various horizons in British Jurassic and Cretaceous rocks, and so material for a genetic study of the forms merely awaits the accumulation of sufficient zonally-collected specimens.

Pygaster, Agass., first appears in the Upper Lias, and is possibly represented in the Middle Cretaceous by *P. truncatus*, Agass. The genus is, however, practically confined to the Jurassic Period.

Holectypus, Desor, originates in the Inferior Oolite, and continues into the lower part of the Upper Chalk (*H. serialis*).

Discoidea, Gray, is an essentially Cretaceous genus, commencing in the Lower Gault and disappearing at about the same horizon as does *Holectypus*.

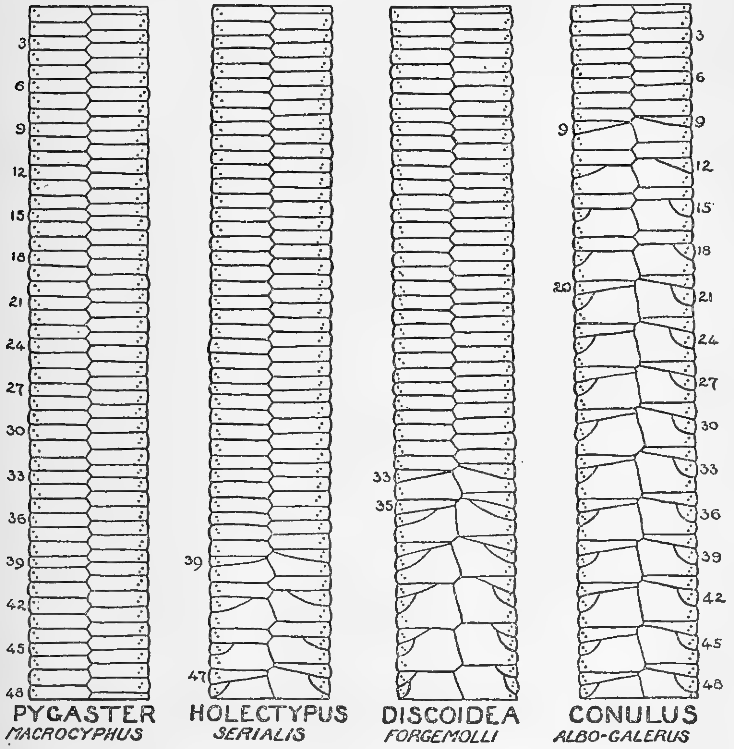


Fig. 2. Comparison of the plate-crushing in four Holectypoid genera.

Conulus, Leske, is another purely Cretaceous genus, first met with in the Upper Gault and persisting to the top of the Upper Chalk.

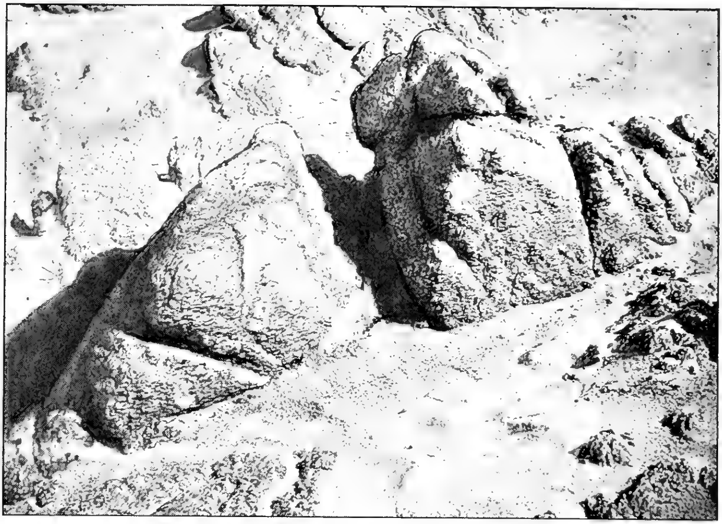
Considered in this order (that of their appearance in time), these four genera exhibit a fairly uniform series. *Pygaster*, with its periproct but slightly removed from the apex, and its well-developed jaws and external branchiæ, shows marked affinities with the Regulares; and *Conulus*, with a marginal periproct and probably no true jaws (when adult), is the most remote from the regular condition.

The four species I have chosen for the purpose of the diagram are, as far as I could obtain specimens, representative of the later specific developments in all four genera. The specimens utilized are all approximately adult.

Pygaster macrocyphus, Wright (the only traceable co-type of which is in the South Kensington Museum), is from the Kimmeridge Clay near Boulogne. Although the adapical regions of the test are considerably broken, enough of the ambulacra can be examined to show that considerably more than sixty consecutive ambulacral plates, counting from the apex, in each ray are simple primaries. Apparently the development of demi-plates does not commence until a region about half-way between the ambitus and the peristome. Examples of *P. semisulcatus* and *P. umbrella* which I have examined show at least an equal postponement of the 'crushing-point', but it is not often that specimens suitably preserved to show the plate sutures are met with among the Jurassic forms.

Holectypus serialis, Deshayes, from the Turonian of Algeria, is perhaps the latest member of the genus known. Two specimens in my collection show the plate sutures very clearly, although the diameter of the larger example is only 15 mm. The first indication of 'plate-crushing' occurs (of course, in set *c*) at plate 39, where this primary becomes wedge-shaped, reaching the median suture by a very narrow strip. Plate 42, the next of the *c* set, is definitely a demi-plate, and plates 41 and 43 meet round it along the median line. Whenever the plates of the *c* set are seen as the ambulacrum is traced towards the peristome, they are found to be demi-plates, whose extension towards the median suture becomes reduced the nearer they are to the mouth. Plate 47 is the first member of set *b* to show a cuneiform shape, and by the time plate 56 is reached this set also is represented by demi-plates, and the median ambulacral suture is entirely formed by the large primaries of set *a*. In *H. depressus* from the Lower Oolites, the crushing of the plates of set *c* is postponed beyond plate 50, and that of the plates of set *b* yet further from the apical system. Thus in earlier Jurassic times this genus would appear to have been similar to *Pygaster* in the structure of its ambulacra, but to have developed in the course of time a far more complex condition than was ever reached by the latter genus.

Discoidea Forgemolli, Coquand, from the ? Senonian of Algeria, exhibits the phenomena of 'plate-crushing' in a degree advanced from that in *Holectypus*. Plates of set *c* begin to appear compressed and wedge-shaped at number 33, and the reduction in size of the plates of set *b* is accelerated to such an extent that while plate 36 (set *c*) is but hardly separated from the median suture, plate 35 is already cuneiform. In a *D. cylindrica* from the Lower Chalk the first indication of crushing in set *c* appears at plate 39, and in set *b* at plate 41. So that in this earlier form the proportionate rate of crushing of the two sets of plates is similar to that in *D. Forgemolli*, but the point at which it commences is postponed by six plates. It will be noticed that in the case of *D. cylindrica* the 'crushing-point' is identical with that in *Holectypus serialis* from a newer horizon. There is thus some overlapping in this feature among the various genera, but in the fully specialized members



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T. O. Bosworth photo.

Wind-eroded Rocks on the Coast of Mull.

of each genus the distinction holds good. The very fact of the overlapping would tend to confirm the supposition that this 'plate-crushing' is of genetic value, and that parallel development takes place among the several genera.

In the case of *Conulus albogalerus*, Leske, from the Upper Senonian, the crushing is markedly earlier in its origin. So much so that, whereas in *Holectypus* and *Discoidea* the ambulacra on the adapical surface of the test seem almost entirely composed of primaries, in *Conulus* the great bulk of each ambulacrum is built of crushed plates. The first indication of crushing in set *c* appears at plate 9, and in set *b* at plate 20. But while in set *c* the plates become small demiplates inserted in the outer angles of the others by the time plate 15 is reached, in set *b* the primary character lingers on until plate 42. Thus the greater part of the median ambulacral suture is made up of the edges of plates belonging to sets *a* and *b*. This perpetuation of the primary plates in set *b* would appear to be a special feature developed in the course of evolution of the genus, for in *C. subrotundus* from the Cenomanian, while the plates of set *c* begin to diminish in size at number 12, and those of set *b* at number 20, the latter set of plates becomes definitely separate from the median suture at number 53.

There seems, therefore, to have been in the history of the development of the Holectypoida a tendency to introduce 'plate-crushing' in the ambulacra to an increasing extent. As this feature may very likely be connected with two other noticeable characters of the progressive development (increase in the height of the adapical surface of the test and narrowing of the ambulacra), it should serve as a useful index to the genetic relationships of the various genera and species. As I have not sufficient material to investigate the ambulacral structures of the other genera of the order, nor the opportunity of collecting sufficient numbers of specimens for working out specific relations within the various genera, I have thought that the above indication of the possibility for important evidence on this branch of evolution might perhaps induce others, more favourably situated in these respects, to continue and amplify the study.

IV.—Wind Erosion on the Coast of Mull.

By T. O. Bosworth, B.A., B.Sc., F.G.S.[1]

(PLATES XXVIII AND XXIX.)

The Ross of Mull is a comparatively low-lying peninsula exposed to the storms and swept by gales from the Atlantic. On these rocky shores are occasional stretches of sand which frequently have been driven inland, forming dunes and patches of blown sand at intervals around the coast. Sometimes the sand is forced up the cliffs and deposited more than 100 feet above the sea, and there are places in the centre of the peninsula where the blown shell-material is quite a noticeable constituent in the soil.

In one instance, the peculiarities of which are here to be described,

[1] With permission of the Director of the Geological Survey.

the dune formation is accompanied by considerable rock erosion. On the north coast 3½ miles north-west of Bunessan, and half a mile west of the bay called Camas Tuath, is a smaller bay marked on the 6-inch map as Traigh na Margaidh. It is one-sixth of a mile wide at the mouth and reaches thence one-fifth of a mile inland. In this inlet, which is bounded by granite cliffs, there is a wide stretch of white sand, which, followed inland, becomes a mantle of blown sand spreading over and banked up against the granite rocks. This sand is decidedly more worn than that on the beach, and the sorting of the grains is more complete. Magnetite grains are abundant in it; and from one sample 5 per cent. by weight was easily extracted with a magnet.

The granite is coarsely crystalline and of homogeneous texture, without any parallelism of minerals or any sign of shearing. The joint planes here are vertical with directions 45° W. of N. and 30° E. of N.

The wearing of the rocks on the sides of the bay and on the hummocky masses more or less buried in the sand indicate within the inlet a prevalent N.N.W. wind, straight up the bay and up the 'slack' which is its landward continuation. The crests of the elongated mounds of sand which have formed on the lee side of the hummocks also have this trend, and the crests of the ripples are at right angles to it.

The hummocks are elongated in the direction about 15° W. of N. They are often undercut and worn to a somewhat conical shape with the point more or less sharpened and facing the wind. (See Pl. XXVIII, Fig. 1.) On these windward ends smooth hollows have been formed in the felspar, and deep narrow-mouthed pits where mica has been, while the quartz stands out as tiny smooth knobs sometimes mounted on diminutive undercut stalks of pink felspar, like a minute collar stud. (See Pl. XXVIII, Fig. 2.)

The surfaces of the rocks and hummocks are highly polished and curiously corrugated, being worn into regular ridges and furrows. (See Pl. XXIX, Fig. 3.) From the windward ends of the hummocks these radiate as from a focus, but on the flat surfaces they are more strictly parallel, trending N.N.W. The ridges vary considerably in dimensions; commonly they are about a quarter of an inch apart, and the furrows say one-tenth of an inch deep, but in some cases the ridges are an inch apart and the furrows one-third of an inch deep, and in others there are as many as ten ridges to the inch. Sometimes there are major and minor corrugations. The furrows are formed in felspar, but each ridge begins abruptly at its windward end with a quartz crystal worn into a smooth polished convex cap and often almost worn away. The remainder of the ridge consists mainly of pink felspar sheltered from destruction by the quartz, and, unless some more quartz is encountered, the ridge dies out in the course of an inch or two. Both quartz and felspar are so highly polished that they have a sub-pearly lustre.

Loose boulders of granite, that probably have not lain long in place, are corrugated like the rocks, and a loose block of basaltic rock from a neighbouring dyke was seen to be fluted in a somewhat similar way, a relatively large crystal of ferromagnesian mineral forming the

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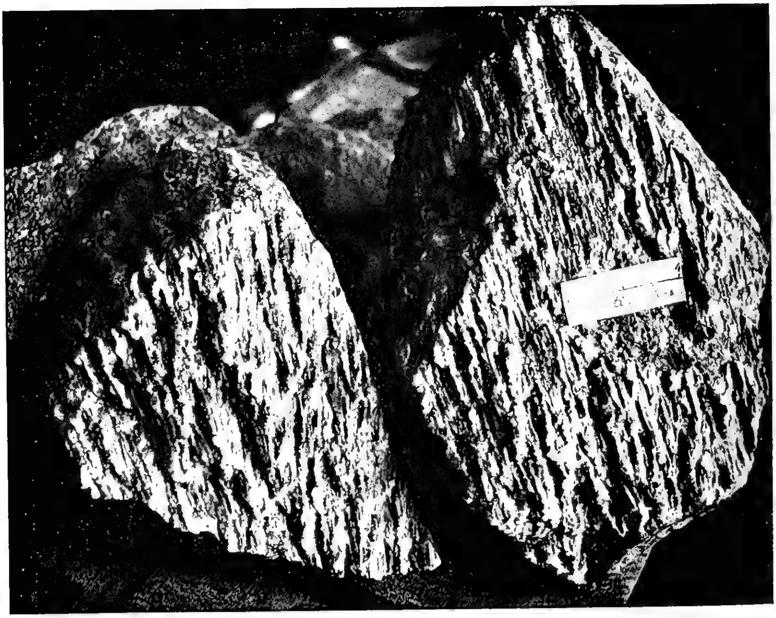

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T. O. Bosworth photo.

Wind-eroded Rocks on the Coast of Mull.

windward end of each little ridge. A few wind-cut pebbles also lay upon the sand.

Such surfaces as these, which thus at every point bear record of the exact direction of the eroding sand drift, can only be formed in places where the direction of the wind is constant. Probably this condition is here almost perfectly realized; the direction of the air currents being determined by the shape of the bay, so that changes in the wind outside affect only their intensity and not their direction. The bearings quoted here are from measurements on one particular hummock; they vary somewhat from place to place in the bay, and in the arm, which branches off to the east, the dunes and corrugations are from west to east.

Higher up among the rocks at the south end of the bay is a slightly inclined 9 foot sheet of mica trap which projects out from the rock side forming a bench whose foot is reached by the banked-up sand. The front of this sill is nearly vertical and is divided up by the joints into some four or five layers of rectangular blocks. The blown sand strikes obliquely against this wall of rock, and at one place every block has had its front top windward corner eroded away (Pl. XXIX, Fig. 4). In some cases several small facets have been cut, meeting in fairly sharp edges. A few of the facets are furrowed, each minute furrow beginning in a ferromagnesian mineral, but generally the corner surfaces are instead almost covered with small pittings, and are conspicuous on account of their peculiar colour. Normal weathering gives the rock a red-brown rough surface, but these corner surfaces appear from a slight distance of a dark-purple plum colour, to which a little polish has added the appearance of bloom. The purple effect is due to the steel black colour in the pittings. It is removed to some extent by acid yielding a solution containing iron. Possibly it is due to a thin film of fine magnetite dust imparted by the magnetite grains in the blown sand.

Thus wind-blown sand is here ever at work on the rocks in advance of the waves, lengthening the bay at its landward end, and so playing some small part in the coast erosion.

EXPLANATION OF PLATES XXVIII AND XXIX.

Plate XXVIII.

Fig. 1. Two of the small hummocks, conical in front, with points towards left-hand lower corner of picture. Both are about 18 inches high.

,, 2. Front of a rock facing the wind. Lower middle part of picture shows projecting knobs of quartz; middle of picture is a more horizontal surface with corrugations; upper middle portion is a vertical surface facing wind, and studded with knobs of quartz. Scale, 6 inches.

Plate XXIX.

,, 3. Two specimens of corrugated rock surface. Left-hand specimen was a surface which met wind obliquely; right-hand specimen an horizontal surface. Scale, 4 centimetres.

,, 4. The sill of mica trap which is met obliquely by the wind. Top front windward corner of each block worn away. Scale, 1 foot.

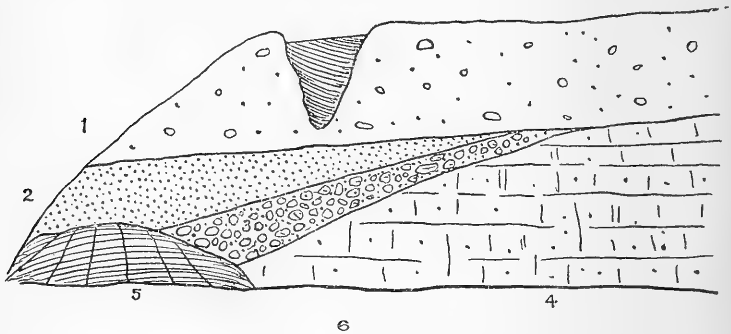
V.—A Buried Valley at North Sea Landing, Flamborough.

By T. Sheppard, F.G.S.

During the last few weeks East Yorkshire seems to have been severely dealt with by wind and hail and flood, and in common with the rest of the area the cliffs have suffered. Geologists, however, are able to profit where others lose, and as a result of disasters can obtain useful information in reference to the structure of a district. Perhaps one of the most interesting exposures that has recently been made occurs at the south extremity of North Sea Landing, Flamborough, where a large amount of cliff has recently slid down on the beach.

There have been two landslides at this particular point; the upper one, which occurs at the top of the cliff at a height of about 125 feet above the sea, has carried away the footpath along the cliff edge, and in other ways has made things disagreeable. Beyond exposing a clean face of purple Boulder-clay, however, it has revealed nothing of particular geological interest.

The second landslide occurs almost immediately below, in the part of the cliff which rises to a height of about 35 feet direct from the beach. There is still a tongue of soft Boulder-clay, which forms a talus, and covers up part of the section, as shown in the diagram. This second landslide has exposed a glacial valley which apparently at one time had an outlet to the sea at this point. As one faces the land, the section occurs immediately to the right of the concrete slope up which the fishing cobbles are drawn.



Section of lower part of cliff at south extremity of North Sea Landing, Flamborough. 1, Basement Boulder-clay, 15 feet; 2, angular chalk 'grut', 6 feet; 3, chalk rubble, 6 feet; 4, chalk with flints, 20 feet; 5, talus; 6, beach.

The upper part consists of about 15 feet of dark lead-coloured Boulder-clay, very different in appearance from that on the higher slopes. This bed evidently represents the 'basement' clay; it certainly is precisely similar to the deposit which occurs immediately above the chalk 'wash' at Sewerby. This Boulder-clay entirely covers the solid chalk at North Sea Landing, as well as the deposits resting in the pre-Glacial hollow. The Chalk itself, which is to the right of the section, is about 20 feet in exposed thickness, and contains thin beds of flint, and the echinoderm *Holaster planus*. Where the Chalk has been cut into by the valley the upper portion is considerably disintegrated and discoloured. This rubble is about 6 feet in thickness in the lower part, and thins out towards the right; and where the Boulder-clay rests directly upon the Chalk it is missing altogether, having probably been planed off by the moving ice.

To the left of the section there is a wedge-shaped mass of fine, clean, angular chalk 'grut', which is about 6 feet thick at the left of the section and gradually tapers off towards the right. This 'grut' is evidently of very early date, as it contains a fairly large proportion of small well-rounded quartzite pebbles, such as occurred at the top of the Wolds in pre-Glacial times.[1] The chalk 'grut' at North Sea Landing is precisely similar to the deposit at Sewerby described by Mr. G. W. Lamplugh[2]; in fact, in general appearance it is precisely similar to that on the buried cliff, though unfortunately there is no beach material exposed at North Sea Landing, nor is this to be expected. The section just exposed at North Sea Landing therefore seems to indicate the position of a pre-Glacial outlet on Flamborough Headland, which has not previously been described. This had been partly filled in by chalk 'wash' in early Glacial times; the whole valley had subsequently been blocked by drift during the Great Ice Age, and had since remained hidden until exposed by the recent landslip.

VI.—The Development of Uralite and other Secondary Amphiboles: a brief History of Research in that subject.

By Albert Wilmore, D.Sc. (Lond.), F.G.S.

In the year 1831 the famous mineralogist and chemist, Gustav Rose, described a mineral which he had observed in his travels in the Urals the previous year.[3] He pointed out that he had found in the greenstones of the Urals crystals with the cleavages and the prism angle of hornblende, but with the external form of augite. The porphyritic crystals of these greenstones are sometimes hornblende, sometimes augite.

In a greenstone near Bogoslowsk, 437 versts north of Ekaterinberg, there are large dark crystals of hornblende with perfect cleavage. They have also the crystal form of hornblende, showing typical symmetrical six-sided sections with two angles of $124\frac{1}{2}°$ when the section is transverse to the ortho-axis, and angles of $156\frac{1}{2}°$ when the section is parallel to that axis. There is often a core of augite, and in the larger crystals this core is surrounded by a comparatively narrow zone of dark hornblende. In the smaller crystals the augite core is very small and sometimes it is quite wanting. To these crystals of hornblende, so clearly derived from augite by some alteration, he gave the name of *Uralite*.

[1] See *The Naturalist* for 1904, pp. 54–6.
[2] Quart. Journ. Geol. Soc., August, 1891, pp. 384–431.
[3] Pogg. Ann., 1831, Bd. xxii.

In giving reasons for the grouping of hornblendes and augites into one family, he called attention to the fact that when hornblende is fused in a platinum or graphite crucible, crystals result which have the form of augite. Augite crystals are found in slags, but never hornblende crystals. The melting-point of hornblende is lower than that of augite. In 1833 Rose gave further localities for uralite.[1]

Meanwhile Professor Glocker had cast doubts on the secondary origin of this uralite; he had suggested that it might be due to hornblende enclosing, in crystallizing, a core of augite, or that an original crystal of augite had had a zonary growth of hornblende formed round it (Schwegger's *Jahrbuch*, Bd. v, p. 373). Rose replied to these suggestions, and insisted on the unity of the augite and hornblende families. He also gave further localities for secondary hornblende.[2] Rose then discussed the question whether hornblende and augite should be considered as two dimorphous substances, and he showed that though their chemical composition is very similar it is not identical. Later on he suggested the possibility of the change from augite to hornblende being due to the higher oxidation of the ferrous oxide of the augite.

These observations of G. Rose are the first systematic descriptions of a secondary mineral, and are the precursors of much important work in connexion with changes in the minerals of rocks which could only be carried out after the application of the microscope to petrological study.

The subject does not seem to have attracted much attention until the era of microscopic petrology had dawned, but from 1876 onwards one finds a continuous series of important papers dealing more or less directly with uralite.

In 1876 J. A. Phillips called attention to the "pseudomorphic origin" of many of the minerals of the greenstones of Western Cornwall.[3] Some of the rocks are gabbros or dolerites, in which the original constituent minerals are occasionally, to a great extent, unchanged, but are sometimes almost entirely represented by "pseudomorphic forms".

In the same year S. Allport described the rocks surrounding the Lands End mass of granite.[4] Allport made an interesting observation which shows that he regarded the process as almost entirely one of paramorphism. "The alteration that has taken place appears to be the result of internal rather than of external action; in other words, it must have been caused by a more or less complete decomposition and re-arrangement of mineral substances in situ, and not to any great extent by the introduction of new material from without."

This seems to have been one of the first suggestions, that the production of hornblende by change from augite is one of simple paramorphism, an idea which was afterwards developed more fully, especially by G. H. Williams. As will be seen later, it does not now seem feasible to regard the change as of so simple a nature, at any

[1] Pogg. Ann., Bd. xxvii, pp. 97–106.
[2] Ibid., 1834, Bd. xxxi, pp. 609–22. Dana gives the date as 1831.
[3] Quart. Journ. Geol. Soc., 1876, vol. xxxii, pp. 155–78.
[4] Ibid., pp. 407–27.

rate in the majority of cases. Rose's original suggestion, though only touching one aspect of the possible chemical changes, was nearer the truth.

In 1880 von John described Flysch gabbros from Bosnia ("Über Kryst. Gest. Bosniens": Jahrb. der k.k., etc., Vienna, 1880), and he stated that the kind of secondary hornblende produced depends upon the composition of the original pyroxene. Brown hornblende results from the alteration of dark diallage, but green hornblende from the alteration of green diallage. The secondary brown hornblende is very strongly dichroic, but the hornblende derived from the light-green diallage is fibrous and almost colourless. The hornblende passes by further change into chlorites.

Cohen (*Sammlung von Mikrophot. von Mineralien u. Gest.*, Stuttgart, 1884) illustrated the development of uralite in his pl. xlvi, figs. 1–4. Fig. 1 shows the beginning of uralitization in the periphery of a crystal, and is taken from a micro-section of the so-called uralite-porphyry from Predazzo in the Tyrol. Fig. 2 shows the beginning of uralitization in the central part of a crystal, and is from a 'proterobase' from near Audlan in the Vosges. Fig. 3 shows complete uralitization; section parallel to the vertical axis, and is again from the uralite-porphyry of the Tyrol. Fig. 4 shows complete uralitization; section nearly at right angles to the vertical axis. It is from the so-called uralite-porphyry of Miask in the Urals. The form is augite, the cleavage that of hornblende.

An important work is Lehmann's study of the crystalline schists of Saxony, etc.[1] In ch. xiii, p. 191, which deals with gabbros and amphibole rocks (Amphibolgesteine), he mentioned a series of secondary minerals, among which are amphibole, saussurite, magnesia-mica, etc. He described the change from pyroxene to amphibole as one of paramorphism. Later, p. 197, he described amphiboles of secondary origin, which are sometimes like smaragdite, sometimes like actinolite. The amphiboles and other secondary minerals are due in part to pressure. An important observation is that the formation of magnetite often accompanies that of amphibole derived from hypersthenes rich in iron.

We now come to the very important series of contributions made by Professor Judd during the years 1885–90. Though not the earliest of the series it may be well to take first the Presidential Address to the Geological Society of London in 1887.[2] This address deals with the morphology, physiology, chorology, and ætiology of minerals. In the section treating of the physiology of minerals Professor Judd pointed out the importance of recognizing the different *structure-planes* of crystals. The most obvious of these are the *cleavage-planes*. These, however, are not the only latent structure-planes in crystals. Brewster, Reusch, and Pfaff had shown long ago that when crystals are subjected to pressure in certain directions their molecules appear to glide over one another along certain definite planes within the crystal, and if we examine optically a crystal which has been treated

[1] *Untersuchungen über die Entstehung der Altkrystallinischen Schiefergesteine*, Bonn, 1884.

[2] Quart. Journ. Geol. Soc., vol. xliii, p. 68 et seq.

in this manner it is actually found to exhibit a series of twin-lamellæ arranged parallel to the so-called *gliding-planes.*

There is still a third and even more subtle set of structure-planes in crystals, those, namely, for which the name of *solution-planes* has been proposed.

In the section dealing with the 'ætiology' of minerals (the causes by which the existing forms, capabilities, and position of minerals and rocks have been determined) Professor Judd compared the change from unstable monoclinic sulphur—by a pressure of 5000 atmospheres—to the stable rhombic form, and that of yellow mercuric iodide, by simply rubbing, into the stable red tetragonal form, with the "paramorphic change of pyroxene into hornblende, which is so frequently exemplified in the earth's crust".

In the next paper to be noticed he explained his now well-known theory of schillerization, and showed the connexion between this process and the planes of discontinuity in crystals.[1] This paper is of importance in connexion with uralitization, as it deals to some extent with augite, diallage, and the amphiboles, and the changes set up in the pyroxenes.

The difference between minerals found at great depths and the same minerals found near the surface is sometimes original—due to pressure and slow growth—sometimes secondary, such as the bands of fluid enclosures, the avanturine structure, and the chatoyant phenomena.

The same phenomena, but more closely connected with the subject of this paper, were further elucidated in a paper by Professor Judd in 1890.[2] In that paper he reviewed the work of Mügge on the diopsides of Ala, of Phillips and Teall on the Whin Sill augites, and showed that augites in the Tertiary basalts of Ardnamurchan present the same features, viz. lamellar twinning parallel to the basal plane (001) and not parallel to the orthopinacoid (100). According to the work of Mügge this may have been caused by pressure. The lamellar twinning or parting of diallage, parallel to the orthopinacoid (100), is due to solution acting along the solution-planes.

There is one other paper by Professor Judd which should be included in this important series.[3] This paper deals with a pyroxene-felspar rock at Oodegaarden, near Bamle, in Norway. This rock has been converted into hornblende-scapolite rock. MM. Fouqué and Michel-Lévy had shown that by fusion (with a trace of sodium fluoride) and slow cooling this hornblende-scapolite rock is, in turn, converted into a pyroxene-felspar rock.

The change of felspar into scapolite may be followed step by step. The solvent which attacked the felspar crystals along their solution-planes, and which acted under statical pressure, contained sodium

[1] "On the relation between the Solution-planes of Crystals and those of Secondary Twinning, etc.: a contribution to the Theory of Schillerisation": Min. Mag., 1887, vol. vii, pp. 81–93.

[2] "On the relation between the Gliding-planes and the Solution-planes of Augite": Min. Mag., 1890, vol. ix, pp. 192–6.

[3] "On the process by which a Plagioclase Felspar is converted into a Scapolite": Min. Mag., 1889, vol. viii, pp. 186–98.

chloride. The felspars of this Oodegaarden rock evidently became saturated along their solution-planes with sodium chloride in solution, and the effect of the internal stresses in the rock masses was to "bring about those chemical reactions by which the felspar-molecules were broken up and their materials united with the sodium chloride to form scapolite".

The pyroxene has undergone a precisely parallel series of changes. The original pyroxene was very nearly colourless, probably an enstatite. It was converted into a schillerized 'bronzite' by enclosures parallel to a pinacoid. This pale-coloured bronzite is, in places, found to be acquiring the characteristic colour, pleochroism, and absorption of brown hornblende.

The last stage in the change of the Oodegaarden pyroxene is seen in certain crystals which, around their edges and in certain patches in the middle, exhibit the full pleochroism, the absorption, and the characteristic cleavage of hornblende. This is often accompanied by 'granulation' of the broad plates of the original pyroxene. The original rock appears to have a perfectly granitic structure, but the derived hornblende-scapolite rock has a granulitic structure.

The effects produced are the results—

(1) of chemical action resulting from statical pressure (schillerization);
(2) of changes induced by the internal stresses set up in a rock during its deformation in the act of flowing (dynamo-metamorphism).

Professor Judd described the change from pyroxenes to hornblende as a 'paramorphic' one, but that from felspar to scapolite as a 'pseudomorphic' one.

Two important papers of a different type by Professor Judd may now be noticed. The first of these is his well-known paper on the Peridotites of Scotland.[1] In this paper he gave a classification of pyroxenes with 'Schiller' varieties, which is here reproduced.

	Unaltered forms.	*'Schiller' varieties.*	*More altered forms.*
Enstatites (*Rhombic*)	Enstatite proper	Diaclastite?	
	Proto-bronzite	Bronzite	Talc?
	Proto-hypersthene	Hypersthene	
	Amblystegite	Hypersthene	Bastite
Augites (*Monoclinic*)	Diopsides	Diallage and	Green diallage
	Augite proper	Pseudo-	and
	Hedenbergite	hypersthene	Smaragdite

An interesting alteration series is given on p. 381 of this paper—

Augite, diallage, green diallage { Smaragdite / Actinolite and / similar hornblendes.

On p. 386 he distinguished 'weathering' changes which produce kaolinization, uralitization, serpentinization from the changes which produce schillerization. The latter is deep-seated, the others are not deep-seated.

The next paper of Professor Judd deals with the Tertiary Gabbros in Western Scotland and Ireland.[2] In it he emphasized most strongly

[1] "On the Tertiary and older Peridotites of Scotland": Quart. Journ. Geol. Soc., 1885, vol. xli, pp. 354–418, pls. x–xiii.
[2] Quart. Journ. Geol. Soc., vol. xlii, p. 49 et seq.

the unstable nature of the minerals of the basic rocks. The felspars are found changed into saussurite, the augites into hornblende, the olivine into serpentine and magnetite. Still further changes may have taken place by which the rock is converted into hornblende schist or gneiss.

Almost contemporary with this important series of papers were several contributions by Dr. Teall. Of these the first was an oft-quoted paper on the Metamorphism of a Dolerite Dyke into a Hornblende-schist.[1] At Scourie in Sutherlandshire occurs a dyke of hornblende-schist, which is clearly the result of metamorphism of a dolerite. In this paper Dr. Teall made a number of very important observations relative to such questions as the various stages in the development of the secondary hornblende and the production of foliation.

Of the two minerals, augite and hornblende, the former appears to be the stable form at high temperatures, the latter at low temperatures, "so that any condition tending to facilitate molecular readjustment must necessarily tend to facilitate the change from augite to hornblende. The enormous pressures brought into operation in the process of mountain-making may not unreasonably be supposed to supply such conditions."

Analyses of the dolerite of the hornblende-schist are given, but apparently the only safe conclusions from percentages which are very similar in the two cases are—

(1) That the change has almost been one of simple paramorphism.
(2) That there may have been some conversion of ferrous into ferric oxide.

Dolerite	FeO	14·71	Hornblende-schist	FeO	11·71
	Fe_2O_3	2·47		Fe_2O_3	4·35

In a paper dealing with some minerals from the Lizard,[2] Dr. Teall described a (probably) secondary hornblende, a very pale variety occurring in a gabbro-schist at Pen Voose. This was analysed by Mr. J. H. Player.

SiO_2	48·8	CaO	12·2
Al_2O_3	10·6	MgO	18·6
Fe_2O_3	1·7	Ignition loss	1·8
FeO	4·7		

On this analysis Dr. Teall remarks: "If this hornblende be secondary, then its composition does not bear out the view that secondary hornblende is derived from pyroxene by a paramorphic change."

In 1885 Dr. Hatch[3] described gabbros passing into amphibolites, the alteration series being—

Normal gabbro, hornblende gabbro, amphibolite, epidote rock.

Another alteration series is suggested, as follows:—

Normal gabbro, uralite gabbro, actinolite or nephrite-schist, serpentine.

[1] Quart. Journ. Geol. Soc., 1885, vol. xli, pp. 133–45.
[2] "Notes on some Minerals from the Lizard": Min. Mag., 1888, vol. viii, pp. 116–20.
[3] "Über den Gabbro aus der Wildschnonau in Tyrol," etc.: T.M.P.M., 1885, Bd. vii, pp. 75–87.

Pressure is clearly seen to have been effective in converting the diallage into hornblende. The crystals of the former were bent, stretched, and partly destroyed. Hornblende is developed along the cracks in patches and round the edges. A large quantity of magnetite has been developed as the result of the change from diallage to hornblende. The extent to which secondary hornblende has been produced is a measure of the schistose character developed in the rock, until, with complete change of the original diallage to hornblende, an amphibolite or nephrite-schist is produced.

The next contribution to be noticed is that of Harker in his Sedgwick Prize Essay of 1888.[1] In ch. vi, on Diabase Sills, etc., it is pointed out that the augite has fringing growths of hornblende, these also traversing it in strings and sometimes extending into the decomposed felspar. This secondary amphibole is always in crystalline relation with the augite from which or in which it grows.

The pseudomorphic hornblende is for the most part truly secondary in the ordinary sense of the word. In one or two examples, on the other hand, there are appearances which suggest that the amphibolization may have begun before the final solidification of the rock, e.g. when a grain of augite is seen partly pseudomorphosed by hornblende which is in crystalline continuity with hornblende moulding the grain.

We now come to some of the more important papers from the pens of the American petrographers. First among these may be taken a paper by G. H. Williams.[2] This a very suggestive paper. It is pointed out that pyroxene and hornblende are two different crystallographic forms of essentially the same molecule. Some experimental work is reviewed. In 1824 Mitscherlich and Berthies melted *tremolite* at the Sèvres pottery works and found that augite resulted on slowly cooling. G. Rose in 1831 had performed a similar experiment with actinolite from the Zillerthal. Fouqué and Michel-Lévy have since corroborated. A second paper by Williams in 1890[3] contains important suggestions upon the whole question of secondary amphiboles. This memoir is intended as a contribution to the study of dynamic or regional metamorphism.

Of the various types of alteration discussed, uralitization occupies a prominent place. It is made to include the derivation of any hornblende, fibrous or compact, from pyroxene. In discussing this process it is pointed out that though it has often been referred to as one of paramorphism it is more than that in many cases. Forchhammer, Rose, and Svedmark have shown that when augite changes to fibrous hornblende, magnetite and often calcite are separated out between the needles.

Williams pointed out that Harrington, of Montreal, had analysed three stages in the alteration from pyroxene to a secondary fibrous hornblende, and found that during the change there was a loss of lime

[1] *Bala Volcanic Series of Caernarvonshire*, Cambridge University Press, 1888.

[2] "On the Paramorphosis of Pyroxene to Hornblende in Rocks": Amer. Journ. Sci., 1884, vol. xxviii, No. 16, pp. 259–68.

[3] "The Greenstone Schist Areas of the Menominee and Marquette Districts, Michigan": Bull. U.S.G.S., 1890, No. 62.

and a gain of magnesia. (This change is, however, far from constant. See, e.g., Teall on the Scourie Dyke.)

It was further pointed out that the schistose structure of the rocks is largely due to the production of fibrous hornblende. This secondary fibrous hornblende does not remain in the area formerly occupied by the pyroxene; amphibole needles are even found along the cleavage cracks of the felspars. Some other points from this important memoir are:—

(1) Brown hornblende passes into green hornblende by the reduction of its iron from the ferric to the ferrous state; afterwards loss of iron produces fibrous and less coloured hornblende.

(2) Very often there is a double hornblende zone round a pyroxene core; first (inner) brown and more compact hornblende, then green and more fibrous hornblende.

Another important United States monograph is that of F. D. Chester.[1] He distinguished between tremolite and fibrous green hornblende in his remarks on rocks at Iron Hill. Tremolite is evidently regarded as colourless or nearly so. Fibrous green hornblende surrounds hypersthene cores, and tremolite fibres are developed irregularly within the core. Much magnetite is set free as the result of the change, which Chester described as a paramorphic one.

It is pointed out that 'uralite' is used in an ambiguous way—

(1) To indicate a substance with the external form of augite, but the cleavage and optical properties of hornblende.

(2) Fibrous hornblende is loosely described as uralite.

The three papers by W. S. Bayley on the Basic Massive Rocks of the Lake Superior Region necessarily contain several references to uralite and uralitization.[2] The first of these papers gives an interesting history of the classification of the gabbros from the time of Hauy. The third article contains an account of the different structure-planes noticeable in some of the augites. Diallage cleavages are accentuated by dark decomposition products, the most abundant of which are tiny irregular black and brown dots. These are scattered everywhere throughout the pyroxenes, but are accumulated most thickly in the neighbourhood of the cleavage lines. Peculiar platy inclusions characteristic of gabbro-diallage are seen in some of the pyroxenes. These are often arranged in straight lines crossing the parting-planes. They are frequently so crowded that the line of inclusions appears as a dark bar crossing the diallage at various inclinations to the cleavage.

In 1888 A. C. Lawson, of the Canadian Survey, made some contributions to our knowledge of the subject.[3] In a chapter on the Petrography of the Keewatin Series he pointed out that the pyroxene of rocks of the gabbro type is more resistant to 'paramorphic change' than the augite of the diabases. Shreds of fibrous hornblende or actinolite derived from augite are observed to have been developed within the substance of the fresh plagioclase, and along its line of

[1] "The Gabbros and Associated Rocks in Delaware": Bull. U.S.G.S., 1890, No. 59.

[2] *Amer. Journ. Sci.*, 1893, vol. i, pp. 433, 587, 688.

[3] Report on the Geology of the Rainy Lake Region: Geol. and Nat. Hist. Surv. of Canada, Montreal, 1888.

contact with the augite. In another part he noticed that secondary hornblende, chlorite, and epidote have been developed very extensively along cleavages and cracks of the fresh plagioclase.

The recent Survey memoir dealing with the north-west of Scotland[1] contains numerous references to the subject. It is shown that hornblende is sometimes compact and gives no evidence of secondary origin, but on the other hand *much* of the hornblende is evidently secondary after pyroxene. Some of the hornblende-felspar rocks of the Lewisian gneiss show hornblende with pyroxene cores (p. 62). The basic dykes and sills also show much secondary hornblende. The famous Scourie Dyke (*vide ante*) is quoted as an example.

The presence of pyroxene cores in hornblende, the occurrence of needles of hornblende in the felspars (p. 93), the extension of the hornblende individuals parallel to the direction of shearing are observations similar to others already noted. Granulation of pyroxene is also noticed.

The larger textbooks of mineralogy and petrology have, of course, devoted some space to a consideration of this subject. Zirkel, in his *Lehrbuch der Petrographie*,[2] discusses "Secundäre Amphibole" at some length. There is a good general summary of the chief observations followed by a discussion of the nature of the chemical changes involved. One observation is worth reproduction. Schwerdt (*Zeit. Geol. Ges.*, 1886, p. 225) records a case of Chiness diorite in which uralitization has commenced in the middle of the augite crystals so that green fibrous hornblende is seen to be surrounded by an envelope of compact augite.

In the chemical discussion it is emphasized that the passage from pyroxene to amphibole is more than a mere paramorphism; it is a change of augite substance into hornblende substance. The analysis of the Ottawa uralite by Harrington is given (*vide ante*). This shows a loss of Ca O of 9 per cent. and a gain of Mg O of 3½ per cent. There is an increase of both ferrous and ferric oxides. There is also an analysis of a uralite derived from the pyroxene of a gabbro from Zwartekoppies (Dahms). This shows *a gain* of Ca O of 6 per cent., a loss of Mg O of 6 per cent., and a gain of Fe O of 3 per cent. These results are obviously quite contradictory, but it is pointed out that the first case concerns a basic rock rich in lime (24·44 per cent.), while the second deals with a rock poor in lime and rich in magnesia and iron oxides.

The deposit of needles and microliths of hornblende in the felspars of many rocks — the so-called erratic (gewanderte) hornblende — receives fairly full treatment, and there is a series of references.

Quite recently MM. L. Duparc & T. H. Hornung[3] have made a most interesting contribution to the literature of this subject. Their paper is entitled "Sur une novelle théorie de l'ouralitisation". They describe the alteration noticed in a fine series of rocks collected in the Northern Urals. These rocks are very 'fresh' and are made up of

[1] "The Geological Structure of the North-West Highlands of Scotland": Mem. Geol. Surv. Great Britain, 1907.

[2] 1893, vol. i, p. 316 et seq.

[3] C.R. Acad. Sci. Paris, vol. cxxxix.

basic labradorite, pyroxene, green hornblende, and magnetite. All the forms and stages of uralitization may be seen, and it is possible to separate completely specimens of the almost unaltered pyroxene and the almost fully uralitized mineral. The results of the mean of two concordant analyses of these extreme cases are given.

	Pyroxene, D. 3·358.	Amphibole, D. 3·213.
SiO_2	50·91	43·34
Al_2O_3	2·64	12·60
Fe_2O_3	—	10·44
FeO	10·07	7·92
MnO	Traces	Traces
CaO	23·33	13·06
MgO	13·30	12·60
K_2O	—	0·02
N_2O	—	1·90
Loss on heating	—	0·22
	100·25	102·10

The authors claim that these analyses dispose of the idea of a dimorphous molecule, and that the remarkable freshness of the rocks preclude any idea of hydrochemical processes. The examination of a great number of sections shows that the manner of the uralitization depends upon the permeability of the pyroxene. If the latter are impermeable the change is only peripheral; if, however, there exists in the pyroxenes "une ligne de pénétration ou un accident quelconque dans la structure" the uralitization is internal. This is interpreted as showing that the pyroxenes after crystallization have been acted upon by the still liquid magma. The primordial magma has first of all allowed the crystallization of pyroxene and basic felspars. Before the complete consolidation of the rock the bath has been modified in composition by the action of mineralizing agents. The bath, thus modified, has reacted upon the pyroxenes, enriching them in alumina and in iron and depriving them of some lime.

It appears probable that the explanation of Duparc & Hornung applies only to certain cases, otherwise one would expect uralitized pyroxenes to be as common in recent rocks as in more ancient igneous rocks, whereas it has over and over again been pointed out that uralitization is rarely found in the more recent basic rocks. The suggestion at once occurs that uralitization is a general term which has been used to describe more than one type of mineral alteration. These types may be tentatively summarized as follows:—

(1) The alteration of diallage to uralite by the action of hot liquids under pressure and at high temperature and containing various dissolved salts, these liquids having penetrated the various planes of discontinuity in the crystals. In this way brown or green more or less compact hornblende may be produced according to the nature of the original pyroxene and the composition of the penetrating fluid.

(2) The alteration of compact secondary hornblende to fibrous actinolite or tremolite, by the gradual leaching out under conditions of moderately high pressure and temperature of more or less of the iron. This process seems to take place in the upper part of the zone of katamorphism, while the former process seems to be characteristic of the lower part of that zone.

These two processes cannot, of course, be sharply separated. There is every possible gradation and combination of the two. The second process may have proceeded to some extent, and then the former may be superimposed, with the result that, in some cases, there has clearly been a passage from pyroxene through fibrous hornblende to compact brown or green hornblende.

(3) There may be magmatic resorption and corrosion of pyroxenes with the result that amphiboles of various kinds, usually aluminous hornblendes, are formed on the periphery, and along and near the planes of penetration, and in the extreme case there may be complete magmatic reconstruction of the pyroxene into hornblende. When this extreme result has been reached it will be clearly impossible to determine the 'secondary' character of the hornblende unless there is a series of partially resorbed crystals to act as a guide. It is, of course, possible to describe such a hornblende as original.

This will probably take place in the zone of anamorphism, and in the upper part of that zone; while the converse change may be looked for in the lower part of that zone, and amphiboles of specific gravity 3 to 3·3 may be converted into pyroxenes of specific gravity 3·2 *to 3·5* approximately.

Note I, on Melting-points of Pyroxenes and Amphibole.—The following results have been published by the authors named:—

	Cusack.	*Doelter.*	*Brun.*
Augite	1187°	1085°	1230°
	1199°	1200°	
Hornblende	1187°	1065°	1060°
	1200°	1155°	1070°

Cusack: vide *Roy. Ir. Acad.*, vol. iv, pp. 399–413.
Doelter: *Tscherm. Min. Petr. Mitth.*, vols. xx–xxii; *Physikalisch-Chemische Mineralogie*, pp. 99–100.
Brun: *Arch. Sci. phys. et nat.*, Geneva, vol. xiii, pp. 352–75.

Vogt, Day, and others have obtained much higher melting-points for the simple pyroxene diopside, up to 1375°.

Allen, Wright, and Clement (*Amer. Journ. Sci.*, vol. xxii, pp. 385–438) give 1521° as the melting-point of the high temperature stable form of the $Mg\,Si\,O_3$. Instead of simply regarding this simple metasilicate as dimorphous they regard it as tetramorphous, as follows:—

Monoclinic pyroxene; rhombic pyroxene (enstatite);
Monoclinic amphibole; and rhombic amphibole.

The pyroxenes are stable at high temperatures, the monoclinic form being the most stable; the amphiboles are low temperature minerals, and probably change into stable pyroxenes at high temperatures. Hence we can understand the formation of pyroxene from amphibole as recorded by Lacroix in the lavas of Auvergne. (See also Harker, *The Natural History of Igneous Rocks*, Methuen, 1909, pp. 155–8.)

Note II, the Angle Relations of Augite and Hornblende.—Take the average prism angle of augite as $87\frac{1}{2}°$ and that of hornblende as $124\frac{1}{2}°$. Now take half of each of these angles. The following important relation is now evident:—

$$\tan 62\tfrac{1}{4}° \text{ is approximately } 1{\cdot}90,$$
$$\tan 43\tfrac{3}{4}° \text{ is approximately } {\cdot}95.$$

That is, the tangent of half the prism angle of hornblende is twice the tangent of half the prism angle of augite.

REVIEWS.

I.—Geological Survey Memoirs on Water Supply.

1. The Water Supply of Hampshire (including the Isle of Wight), with Records of Sinkings and Borings. By William Whitaker, B.A., F.R.S., with contributions by H. R. Mill, LL.D., W. Matthews, M.Inst.C.E., and J. C. Thresh, M.D. 8vo; pp. v, 252, with two maps. Price 5*s.*

IN our volume for 1909 (p. 180) we drew attention to Mr. Whitaker's *Water Supply of Kent*, and now he has prepared an elaborate account of the springs and streams, the wells and borings of Hampshire. In both works are embodied the result of labours extending over many years, and including experience gained by field work during the geological survey of the respective counties.

The deepest boring in Hampshire, made during the years 1838–51 at Southampton, was carried to a depth of 1317 feet through Tertiary strata without reaching the base of the Chalk. This is not surprising, as the estimated thickness of that formation in the Isle of Wight is more than 1700 feet. The oldest formation known in the county is the Wealden, above which there occur a continuous series from the Lower Greensand to the Chalk, and the most complete series of Eocene and Oligocene strata known in any county, the Thanet Beds only being absent. The chief water-bearing strata are, in order of importance, the Chalk, Lower Greensand, Upper Greensand, and Bagshot Series.

An interesting and instructive map of the valleys of the Terl and Itchen is contributed by Mr. Matthews, the object being to indicate the position of eighty-six wells, and the contour-lines in the surface of the underground water in the Chalk. The data on the map show (with two exceptions) the water-level in February, 1899. It is noted that the surface-contours of the land, although not coinciding with the water-contours, have in general a distinct relation to them; nevertheless, the water-contours "will obviously be moving with the seasonal and other variations in the water-levels, and those represented on the map can only be taken as showing average and approximate levels". Thus gaugings made between 1884 and 1899 prove that seasonal "variations range from about 5 feet in wells in the low ground, to as much as 63 feet in the case of wells sunk at the higher elevations".

Mr. Whitaker remarks that Hampshire is noted for the largest spring supply in the kingdom, that of the Portsmouth Water Company, which is derived from chalk water; the springs at Havant and Bedhampton yielding from 11 to 21 million gallons a day.

Many intermittent streams or bournes, swallow-holes, and other phenomena are described; and some particulars relating to the rivers are given.

The records of strata passed through in wells and borings, and analyses of water (many of which have been contributed by Dr. Thresh) occupy the main portion of the work. Sundry mineral waters are noted, mostly chalybeate, those of Shanklin and Chale being the best known. It is stated that Bembridge is supplied from a shallow well in the Bembridge Limestone, known as "Centurion's or St. Arian's Well". The former name has been regarded by some as a misnomer, recorded by the Ordnance Survey instead of St. Urian's (here given as St. Arian's). A bibliography contains lists of publications of the Geological Survey, the Local Government Board, and of other works that bear on the water supply of Hampshire. Particulars relating to the rainfall, accompanied by a map, are contributed by Dr. Mill.

2. The Water Supply of Oxfordshire, with Records of Sinkings and Borings. By R. H. Tiddeman, M.A., F.G.S., with contributions by H. R. Mill, LL.D. 8vo; pp. iv, 108, with map. Price 2*s.* 3*d.*

THIS work has been appropriately prepared by Mr. Tiddeman, who studied geology under John Phillips at Oxford, and after many years service on the geological survey retired to the neighbourhood of his Alma Mater.

The strata which come to the surface in the county include the entire Jurassic series, the Cretaceous from the Shotover Sands and Lower Greensand to the Upper Chalk, together with Reading Beds, London Clay, Pleistocene, and Recent deposits. The principal water-bearing strata are the Inferior and Great Oolite Series, Corallian, Lower and Upper Greensand, Chalk, and Valley Gravel. The deepest boring, that at Burford Signet, made during the years 1875–7, was carried to the base of the New Red Sandstone Series (depth 1184 feet), and then into Coal-measures (226 feet), the total depth being 1410 feet. The object was apparently to reach Coal-measures, but why no further proceedings were taken when those strata were reached has not been made known. As a rule the waters obtained in Oxfordshire beneath the Oxford Clay and Kellaways Beds have proved to be saline, notably at Oxford itself, at Upper Arncot, Bampton, and Kidlington. Where not covered by Oxford Clay good supplies have, as a rule, been obtained from the Great Oolite beneath the Forest Marble and Cornbrash, and from the Inferior Oolite, as at Bicester. Saline waters have been encountered also in the Lower Greensand beneath the Gault at Shillingford. Mr. W. W. Fisher, who has contributed records of many analyses, remarks that in the waters below the Oxford Clay the amount of alkaline salts is usually so great that the supplies are unfit for domestic or industrial purposes. He believes that the alkalies are normal constituents of the strata, and that they have become concentrated in situations where little or no circulation has been possible. Long-continued pumping ought in these circumstances to improve the supplies.

Dr. Mill contributes a map and explanatory notes on the rainfall. There is also a bibliography, drawn up on similar lines to that noticed in the Hampshire Memoir.

II.—Geology in the Field. The Jubilee Volume of the Geologists' Association (1858–1908). Edited by H. W. Monckton and R. S. Herries. Part III. pp. 433–660, with 6 plates. London: Edward Stanford, 1910. Price 5*s*. net.

IN the March Number of the Geological Magazine we called attention to the issue of the second part of this Jubilee Volume. The third part has now been received, and it contains nine articles.

"The Weald" is dealt with by Mr. Herries, who first briefly discusses the great anticline, the successive stages of elevation, the river-systems, and the denudation. The main characters of the different formations from the Purbeck Beds to the Upper Greensand are then described, and some account is given of Pleistocene and Recent deposits. Finally the author sums up the knowledge acquired by the various deep borings.

"Northamptonshire (including contiguous parts of Rutland and Warwickshire)" is the title of the second essay, contributed by Mr. Beeby Thompson, who likewise refers to the local deep borings, and thus deals briefly with Archæan and other formations not exposed at the surface. Those which are to be seen in the field include the members of the Jurassic Series from the Lower Lias to the Oxford Clay, together with sundry Pleistocene and Recent deposits. In the higher stages of the Lower Lias the author recognizes in upward succession the following Ammonite-zones: *Jamesoni*, *Pettos* (described by him in 1899), *Ibex*, *Henleyi*, and *Capricornus*. The Upper Lias is divided into "eight subsidiary zones, or sets of beds", and is covered conformably by the representatives of the Inferior Oolite. A zealous collector of fossils, Mr. Thompson has added largely to our knowledge of the palæontology of the different strata which occur in Northamptonshire.

"Lincolnshire" is described by Mr. Jukes-Browne, who took a considerable share in the geological survey of the county. Strata of Triassic age are first described, and a record of the Boultham boring, for the water supply of Lincoln, is given on the authority of Mr. Henry Preston. A good supply of water is stated to have been obtained from the Keuper Sandstones at the depth of 1563 feet. This supply, though abundant, proved to be saline; but we are informed by Mr. Preston that a really good supply for Lincoln has since been obtained from the Bunter near Retford. The author gives particulars of the several divisions of the Lias, of the Inferior Oolite Series with its basal ironstone worked at Greetwell, of the higher Jurassic strata up to the Kimeridge Clay, and of the Cretaceous Series. After describing the Glacial Drifts he expresses his dissent from the view of Mr. Harmer that the Honington and Lincoln gaps were formed during the Glacial epoch by the overflow of a lake caused by the advance of an ice-sheet.

"Nottinghamshire" is described by Professor J. W. Carr, who deals with strata from the Millstone Grit to the Lower Lias, a series marked by great unconformity at the base of the Permian. The author remarks that "Where the junction of the Permian and Trias is seen there appears to be a perfectly conformable passage from the one to the other, but the Triassic strata rest in succession on all the divisions of the Permian, and to the west of Nottingham the Trias overlaps the Permian, and lies directly upon the Coal-measures". These conditions suggest that some movements were in progress during Triassic times leading to local erosion of the Permian. Some account is given of the superficial deposits and the bone-caves of Cresswell Crags.

"The Lower Carboniferous Rocks of Derbyshire" are the subject of an essay by Mr. Arnold Bemrose, who briefly refers to previous excursions to the district. The Carboniferous Limestone and its zones of fossils, first investigated in detail by Mr. C. B. Wedd, the toadstones, the dolomitized limestone, the caverns, and the lead-mines, all receive attention. The so-called Yoredale Rocks are described under the heading of "Limestone Shales" ("Upper Limestone Shales" would have been better); the Millstone Grit is described, and there is a brief account of the "Sands and Fire Clays in the Mountain Limestone", which are stated to be pre-Glacial. Glacial Drift, cavern deposits with Pliocene and Pleistocene mammalia, Tufa, and warm springs are also described.

"Staffordshire" is treated by Dr. Wheelton Hind, who first deals with the intrusive rocks of Rowley Regis and other places, and with the Silurian. The Carboniferous Limestone Series is next described, and then the Pendleside Series, which after all is a portion of the Limestone Series. Special attention is given to the life-zones in these groups, as well as in the Millstone Grit Series and Coal-measures. The Triassic, Pleistocene, and Recent deposits are briefly described.

"East Yorkshire" is the subject of an article by Mr. Herries, who has to deal with a long list of formations between the Lower Lias and Upper Chalk. With the aid of many illustrative sections and his personal knowledge of the strata and their fossils, an excellent summary is given of the main features of this attractive area, and particularly of the coast-sections between Redcar and Bridlington.

"The Lake District and Neighbourhood—Lower Palæozoic Times" and "The Lake District and Neighbourhood—Upper Palæozoic and Neozoic Times" are the titles of two essays contributed by Dr. J. E. Marr. He deals with many formations from the Skiddaw Slates, which represent Arenig and possibly Tremadoc and earlier beds, and the Borrowdale Series grouped as Llandeilo, to the Lower Lias of the area west of Carlisle, and the Glacial and more recent deposits. The various igneous rocks are also described. It is not certain that Rhætic beds are absent, but their presence has not been proved owing to the covering of Glacial drifts. The leading fossils and zonal divisions in the Carboniferous and older Palæozoic rocks are duly pointed out. The author observes that a "great hiatus occurs above the Carboniferous rocks, for the highest Coal-measures, the whole of the Permo-Carboniferous rocks, and the lowest Permian strata as developed elsewhere, are absent". Here a good deal depends on what may be included in "Permo-Carboniferous". The complex physical changes, the main faults and flexures that were produced after Lower Palæozoic times, and again after Carboniferous times, and their influence on the present physical features, are concisely described.

(*Part IV will be reviewed next month.*)

III.—Report on the Mines and Mineral Resources of Natal (other than Coal). By F. H. Hatch, Ph.D., M.I.C.E. Published by order of the Natal Government. London: Richard Clay and Sons, 1910.

A CLEAR statement as to the actual mineral wealth of a country and the present stage of its development is seldom afforded us, for where so many interests are at stake an unbiassed account is generally withheld. When, therefore, we have the opinion of an expert of such wide experience as Dr. Hatch we ought to be truly grateful. It is not, however, our province to discuss the commercial attitude of this report, nor is it for us to say whether it is politic to make known the results achieved by individual and pioneer undertaking.

Though not optimistic Dr. Hatch is certainly not wholly pessimistic as to the future mining industry of Natal. What the colony has done up till 1908 is forcibly shown by the statistical tables on p. 125, in which, by the way, the author luxuriates in a ton of 2440 lb.

Geologists will be chiefly interested in the author's succinct outline of the general geology of Natal and Zululand, though some will not unhesitatingly accept his correlation of the Table Mountain Sandstone of Natal with the Waterberg Sandstone of the Transvaal. Useful, too, are the notices of the occurrence and distribution of the metalliferous deposits in the colony. With the exception of iron, nickel, and molybdenum the metals appear to be chiefly confined to the complex of rocks older than the Table Mountain Sandstone and included by Dr. Hatch in the Swaziland System. The Witwatersrand formation is not recognized, and the auriferous conglomerates ('bankets') are considered to be contemporaneous with the Swaziland Beds, and therefore to be older than the Banket formation of the Rand. It is disappointing to learn that the iron-ores nowhere appear to be of any great thickness, and that limestones suitable for employment as a flux are of rather rare occurrence in Natal.

To further the mining industry of the colony Dr. Hatch considers a geological survey, such as was commenced in 1898 and precipitately abandoned in 1905, to be an important factor.

IV.—Geology. By Professor J. W. Gregory, F.R.S. 8vo; pp. 140, with 41 text-figures (including a map). London: J. M. Dent and Sons, Ltd. No date. Price 1*s*. net.

THE little work before us is one of a series of Scientific Primers, which are intended to give a simple and general account of the present state of knowledge in various branches of science. At the outset we must find fault with the publishers for not inserting a date either on title-page or in preface—a very serious omission in a work of which the aim is to be 'up to date'.

In an introductory textbook it is always difficult to know how far the knowledge of the reader can be taken for granted in dealing with the facts and phenomena. In this respect Professor Gregory has succeeded as well as possible, considering that he gives special attention to the materials of which the earth is made, and he rightly refers to Sir W. Tilden's primer of Chemistry for an explanation of chemical processes. Commencing with a short account of the early history of the earth, he passes on to the study of rocks, dividing them into Primary and Secondary, the former including all the Igneous rocks and the latter all the Aqueous or Stratified rocks. This is not in accordance with the general usage of the terms, and is to be deprecated; but the descriptions of the rocks and of their method of formation are clear and instructive. More generally interesting is the section on Physical Geology, in which modern agents and the arrangement of rocks in the field are dealt with. Here we note that the author applies the term erosion to the widening of a valley, and corrosion to the cutting of a gorge. The term erosion is by most geologists employed for all kinds of denudation. Under Historical Geology the author gives a brief account of fossils and of the geological systems, and introduces a short notice of Gondwanaland, which is illustrated by a map of the world in the Upper Carboniferous era.

The primer should prove useful to general readers as well as to students and science-teachers, and is well calculated to stimulate further inquiry.

V.—The Miner's Guide. By F. P. Mennell, F.G.S. London: Gerrards, 1909. 4*s*. net.

PRESENT-DAY civilization imposes a heavy toll on the mineral resources of the globe. There is no metal that is not turned to some use. There is no quarter of the globe, not excepting the Polar regions, to which the discovery of mineral wealth does not instantly attract public attention, and there is no nation in the possession of more real and prospective mineral wealth than that which lies within our own empire. Yet how few are able to distinguish one mineral from another, or have any idea as to the rocks in which mineral deposits are likely to occur! Elaborate treatises, and textbooks beyond count, are on the market; but most of these are written for the initiated and are not serviceable to the untrained, by whom the want of a clearly written and practical guide has long been felt.

In *The Miner's Guide* Mr. Mennell has, we think, successfully supplied this deficiency in our scientific literature. How rocks and minerals are formed, how they occur, by what means they can be distinguished, and how their value may be ascertained, are made clear to all who possess an elementary knowledge of chemistry. Quite fittingly, the author illustrates his text with examples taken from his wide knowledge of the mineral deposits of South Africa, Rhodesia in particular. Other countries are referred to, but all too briefly. Coal and oil are summarily dismissed, and we are erroneously informed that the "well-known coalfields" of Ireland are of Silurian age.

The practical nature of Mr. Mennell's clever outline is its chief attraction, but we think that a book dealing with a subject of such general interest possesses an educational value, especially as in this instance the information is obtained at first hand, and the writer has the ability to present his subject in a clear and concise manner.

VI.—Index to Desor's Synopsis des Echinides Fossiles. By F. A. Bather, M.A., D.Sc., F.R.S. Avec une note sur les dates de publication du *Synopsis* par Jules Lambert. Published by the Author, Fabo, Marryat Road, Wimbledon, England, May, 1910. Price to subscribers, 7*s*.

THIS Index, to the preparation of which the Geological Magazine drew attention some time ago, has now been published and should prove of great use to every worker on Echinoids, whether fossil or recent, and to those who, without claiming to be specialists, frequently have occasion to look up a name. Reference is made particularly easy by the fact that the Index is arranged in two parts, the first under the names of species in alphabetical order, the second under the names of the genera, the name of each genus being followed by a list of the specific names that are in any portion of the book associated with it. The value of such an Index will be more apparent when it is remembered that the *Synopsis* was issued in parts and that several of the pages were cancelled, additions being made later on. Also there were several series of Addenda, and various names occur either in the plates, or in the tables, or in foot-notes, to which reference is by no means easy; in fact, many of them almost entirely escape observation.

Systematists have long been puzzled by the fact that this original *Synopsis* was issued in separate parts, and that owing to the destruction of the original wrappers they were quite unable to determine the dates of the various names that occur in it. This task has now been accomplished for them by Mr. Jules Lambert, who, together with the late P. de Loriol, spent many years in trying to obtain the necessary details. The whole of the results are summarized in a collation of a supposed bibliographically complete copy.

Dr. Bather deserves the gratitude of his fellow-workers for undertaking this laborious task, and we may express a hope that their gratitude will be shown by a speedy sale of the work.

VII.—Brief Notices.

1. Hanging Valleys.—In the Bulletin of the American Geographical Society (1909) Professor D. W. Johnson deals with two questions involved in the problem of glacial erosion: (1) Are hanging tributary valleys a reliable indication of glacial erosion of the main valley? (2) May not hanging tributary valleys result from glacial widening of the main valley, instead of from glacial deepening? In the paper the author discusses the origin of hanging valleys, and deals with a number of glaciated valleys in Europe.

2. The Relation of Geology to Topography.—Professors D. W. Johnson & F. E. Matthes contribute a chapter with this heading to Breed & Hosmer's *Principles and Practice of Surveying* (New York). After pointing out the value of a knowledge of geology to the topographer, as giving him "some understanding of the conditions under which the surface was formed", the writers point out by a series of diagrams the differences between accurately and inaccurately mapped mountain areas. They show also how correct contouring of

a district brings out the detail of glaciation, alluvial fans, volcanic features, dome mountains, and general physiography or topographical geology.

3. Oil Shales of Canada and Scotland.—Dr. R. W. Ells has just issued in the Department of Mines, Canada (Ottawa, 1910), a long report on the oil-shale industry of Scotland, New Brunswick, and Nova Scotia. This report treats of the geology, history, statistics, analyses, cost of plant, commercial value, and many other points useful to those interested.

4. "Elephants' or Buffaloes' Wallows" the work of Earthworms.—*The South African Journal of Science* is the organ of the South African Association for the Advancement of Science, and is a monthly record of science and economics. In the part for February, 1910, J. A. H. Armstrong writes on the geology and mineralogy of Natal, and he refers incidentally to those curious pits or hollows known as "elephants' or buffaloes' wallows". Setting aside the older theories as to their origin, (1) wallow holes, (2) native iron-ore digging, (3) ancient gold-diggings, (4) percolating waters, Mr. Armstrong thinks they are the work of earth-worms alone. He gives a number of strong arguments in favour of his views, and seems to have made a singular and thoughtful observation.

5. Mount Etna.—On March 23 this volcano burst forth into activity after a series of minor earthquakes, the outbreak being the most violent since the great eruption of 1892. Streams of lava issued from five craters, and united to form a great stream that moved at the rate of more than 60 feet an hour, and was estimated to be 12 feet high and more than 1500 feet in width. Quantities of scoriæ were also ejected mainly from the highest crater. The lava-stream subsequently divided, portions extending to the Galvagna district, south of Mont San Leo, approaching Borello and also Nicolosi. Ultimately more than fourteen craters were in eruption. On the evening of March 26 the volcanic activity ceased, but a renewed eruption, of less intensity, was reported on March 28, and on April 9 it was announced that Etna was again in violent eruption.

6. The New Zealand Geological Survey in Bulletin No. 7 (New Series), 1909, has issued a report on "The Geology of the Queenstown Subdivision, Western Otago Division", by Mr. James Park. This is evidently an attractive district, as Queenstown "is picturesquely situated on the raised lake-beaches and great moraine overlooking Queenstown Bay and Frankton Arm. Its scenic marvels and sunny salubrious climate have made it the chief centre of the tourist traffic in the South Island". The geological formations consist mostly of mica-schists grouped as Palæozoic, with strata grouped as Lower Miocene (Oamaru Series), Pleistocene. Boulder-clays, moraines, and terrace-gravels, and Recent alluvial deposits. Evidence is given of overthrusting in the older schists, whereby wedges of Miocene strata have been included along certain thrust-planes, a feature of remarkable interest. Proof is also presented to show "that the Lake Wakatipu region was covered by a continuous ice-sheet of vast depth in the Pleistocene period—a continental ice-sheet that reached to the sea, and probably covered the greater part of the South Island".

Gold-bearing lodes occur in the schists, but alluvial mining has been by far the most productive source of the metal. Igneous rocks do not occur in situ, but many pebbles and boulders occur in the fluvio-glacial drifts, and these are described. The work is fully illustrated by maps, sections, and pictorial views.

7. Board of Agriculture.—We are glad to note that Dr. J. J. H. Teall, F.R.S., Director of the Geological Survey and Museum, is a member of the Committee recently appointed by Earl Carrington to advise the Board on all scientific questions bearing directly on the improvement of agriculture. A carefully surveyed geological map on the scale of 6 inches to a mile is the best foundation for the more detailed study of soils, and indeed for appraising the value of an estate. As we noted in reference to Soil Surveys in the United States (Geol. Mag., 1908, p. 277), the so-called 'soil-maps' are geological maps representing the subsoils or geological formations (whether Solid or Drift), there is no attempt to map the constantly varying soils, but information relating to their depth and character is given in many places on the maps from data obtained by means of spade or hand-borer.

8. "Sketches of Gaspé" is the title of a little book by Mr. John M. Clarke (Albany, 1908), in which the author gives an interesting account of the scenery, geology, and of many other matters relating to "that vast peninsula of Eastern Quebec which lies between the mouth of the St. Lawrence River and the Bay of Chaleur, facing the waters of the Gulf of St. Lawrence".

9. Geological and Petrographical Researches in the North Urals.—"Recherches géologiques et petrographiques sur l'Oural du Nord, le bassin de la haute Wichéra," by Professor Louis Duparc, aided by Professor F. Pearce and Miss Marguerite Tikanowitch (Mém. Soc. Phys. et Hist. Nat. de Genève, xxxvi, 1909, pp. 33–210). In this work the authors describe the eruptive rocks (diabases) which are generally intrusive in the metamorphic or pre-Devonian rocks, and these 'crystalline schists' are also described in detail. Middle and Lower Devonian, Carboniferous, and Quaternary deposits complete the list of formations represented. Brief descriptions only are given of them, attention being devoted to the geological structure and physical features, and to the mode of occurrence and origin of the iron-ores. The memoir is fully illustrated by pictorial views, plans, geological sections, and microscopic rock-sections.

10. The Waters of the Great Lakes of North America are described by Mr. R. B. Dole (Journ. New England Water Works Assoc., xxiii, 1909). Samples were collected monthly for a year from each lake, and a tabular statement is now given of the mineral analyses. Around Lake Superior igneous and crystalline rocks predominate, and the water contains on the average sixty parts per million of solids; whereas Lakes Erie and Ontario contain about two and a half times the amount of solid constituents, due mainly to material derived from calcareous sedimentary formations. The lakes are almost invariably softer than their affluents, as might be expected from the effects of direct rainfall. The suspended matter is practically all deposited by sedimentation.

11. Sand-Barytes from Kharga, Egypt (Proc. U.S. Nat. Museum, xxxviii, 1910).—Mr. Joseph E. Pogue describes and illustrates sundry forms of Sand-Barytes. The figures recall to mind examples of selenite charged with sand-grains, the occurrence of which in the Oldhaven Beds has been noted by Mr. Whitaker. As the author remarks, calcite, gypsum, and barite are distinguished above all other minerals by the large quantities of sand which they can enclose upon crystallization. The specimens he describes were probably formed by the deposition from solution of barium sulphate in the interstices of loose sand during the consolidation of the Nubian Sandstone.

12. Sections from Deptford and Catford to Plumstead.—Mr. R. H. Chandler has contributed very useful detailed accounts of sections exposed by the two new sewers: Deptford to Plumstead and Catford to Plumstead (Trans. West Kent Nat. Hist. Soc. for 1908–9, 1910). The particulars are systematically recorded and illustrated by map and sections. Strata from the Chalk to London Clay with superficial deposits were encountered; and in the low-level sewer from Deptford, during construction, more than 3,000,000 gallons of water were pumped from the Chalk in the course of twenty-four hours. Remains of Mammoth and *Bos primigenius* were obtained from the Valley Drift at Greenwich.

13. Fossils in the Algonkian of Scandinavia.—In the Stockholm "Geologiska Förhandlingar", vol. xxxi, 1909, p. 725, Dr. A. E. Törnebohm announces the discovery of fossils in a crystalline limestone at the northern end of the Great Arfven Lake, west of Lake Wener, Sweden, as well as in the Berikalk of Gudbrandsdal, Norway. The appearances in question have been known for some time, but have only recently been determined by Professor Rothpletz as calcareous algæ. Beside these Dr. Törnebohm has found other structures which appear to be of organic origin. The whole microscopic look of the rocks is that of certain younger limestones known to be composed of fragments of organisms.

14. Victorian Fossils.—Mr. Frederick Chapman continues his energetic attempt to describe the new or little known Victorian fossils in the National Museum, Melbourne, in the "Proceedings of the Royal Society of Victoria". His tenth contribution contains worms and Crustacea, and includes Silurian *Trachyderma* of two species, two interesting forms of *Turrilepas* from the same formation, a *Ceratiocaris*, and a *Xiphidiocaris*. Mr. Chapman invariably draws his own figures, and if his efforts in that direction are a little crude, we may rest assured that his detail is extremely accurate.

15. Cretaceous Plants.—Messrs. Stopes & Kershaw describe in the *Annals of Botany*, April, 1910, some pine leaves from the Cretaceous of Japan, and discuss their relationship with other Cretaceous species, and with the living forms of America. Incidentally the authors diagnose the genus *Prepinus*, Jeffrey, 1908, as that author apparently forgot to do so. In a second paper Dr. Stopes describes the internal anatomy of a leaf of *Nilssonia orientalis*, Heer, also from Japan. The result of the examination of this specimen seems to show it to be primitively Cycadean in character.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

June 15, 1910.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Natural Classification of Igneous Rocks." By Dr. Whitman Cross, F.G.S.

The author reviews the various sytems of classification which have been proposed. He discusses the origin of the difference of composition of igneous rocks due to: (1) primeval difference, (2) magmatic differentiation, (3) assimilation; and points out that differentiation and assimilation are in a measure antithetical processes.

If the deep-seated magmas of large volume have acquired their various chemical characters in different ways, it appears at once evident that this primary genetic factor cannot be used in classification, unless the characters of different origin can be distinguished in the rocks.

Classification by geographical distribution of chemically different rocks is considered, and the groupings proposed by various writers are discussed; and it is shown that the rocks of the Pacific zone of North America indicate that they possess provincial peculiarities of interest, but that these are not by any means identical with the features emphasized by Becke and others as characterizing the Pacific kindred.

The factors of magmatic differentiation are then reviewed. The aschistic and diaschistic magmas of Brögger and the 'dyke rocks' of Rosenbusch are discussed; and it is contended that certain dyke rocks of Colorado show a notable exception to the rule postulated by Rosenbusch. The conclusion is reached that the sharp distinction between the two 'dyke rock' groups is a purely arbitrary one, resting on an unproved hypothesis.

A discussion on the classification by eutectics follows, and the writings of G. F. Becker and J. H. L. Vogt on this subject are criticized. The view that graphic, spherulitic, and felsitic textures are characteristically eutectic is considered to be incorrect, and it is contended that magmatic classification by eutectics is fundamentally weak, because it rests on hypothesis, because it does not apply to all rocks, and because it does not allow for the entire magma of most rocks. A classification by eutectics may, in the future, be realized; but it seems inevitable that it must be a classification for a special interest, not for the general science of petrography.

The author considers that the distinction between felspathic and non-felspathic rocks which has been so prominent in current systems is not only unnatural, but is in the highest degree arbitrary.

The use of texture is then discussed, and it is shown that classification by occurrence, as determining texture, or by texture, as expressing the broad phases of occurrence, is based on long disproved generalizations made from limited observation. The "American Quantitative System of Classification" is then briefly dealt with, and the following general conclusions are formulated:—

"The scientific logical classification of igneous rocks must apparently be based on the quantitative development of fundamental characters, and the divisions of the scheme must have sharp artificial boundaries, since none exist in Nature.

"Chemical composition is the fundamental character of igneous rocks, but it may be advantageously expressed for classificatory purposes in terms of simple compounds, which represent either rock-making minerals or molecules entering into isomorphous mixtures in known minerals. It is probable that the magmatic solution consists of such molecules, and that the norm of the 'Quantitative System' is a fairly representative set of these compounds.

"The actual mineral and textural characters of igneous rocks are variable qualifiers of each chemical unit, and should be applied as such to terms indicating magmatic character."

2. "The Denudation of the Western End of the Weald." By Henry Bury, M.A., F.L.S., F.G.S.

There are two main theories of Wealden denudation—(1) attributing the removal of most of the Chalk to marine planation; and (2) denying planation and relying solely on subaërial denudation. Professor W. M. Davis's suggestion of a subaërial peneplain forms a sort of connecting link between the two.

The evidence in favour of planation which Ramsay and Topley brought forward is inconclusive, and might plausibly, if it stood alone, be attributed to pre-Eocene causes. On the other hand, Prestwich's arguments against planation are equally weak, while the Chalk plateau to which he draws attention strongly supports Ramsay's views. The distribution of chert is fatal to Professor Davis's hypothesis, and very difficult to account for, except on the marine theory.

In the case of the River Blackwater it can be proved that, long after the Hythe Beds of Hindhead were uncovered, the river-system remained extremely immature, and this affords very strong grounds for the acceptance of the marine hypothesis.

The evidence of the other western rivers is less conclusive, though the Wey and the Mole both provide minor arguments pointing in the same direction. The anomalous position of the Arun, at the foot of the northern escarpment of the Lower Greensand on either side of the Wey, is almost certainly due to comparatively recent captures from the latter river, and affords no ground for assuming a river-system of great age matured on a Miocene peninsula.

There is no proof that any of the existing connexions between rivers and longitudinal folds are of a primitive character, and, on the other hand, there are many alleged examples of transverse disturbances having served as guides to consequent rivers. This again, on the whole, supports the marine hypothesis, especially if, as there are reasons for believing, the longitudinal folds are older than the transverse.

3. "An Earthquake Model." By John William Evans, D.Sc., LL.B., F.G.S.

This model is designed to show the successive conditions that result in an earthquake shock—

(1) Slow relative movement between two extensive portions of the earth's crust lasting over a long period, and causing
(2) a state of strain in the intervening tract, leading to
(3) fracture which relieves the strain and allows
(4) the adjoining portions of the rock on either side to fly back by virtue of

their elasticity, so as to resume as far as possible their original relation to the rock-masses with which they are still connected. This movement of release may give rise to two kinds of periodic disturbance:

(5) short-period vibrations, due to a sudden arrest by an obstacle and constituting the earthquake properly so called, and

(6) a slower backward and forward swing of the rock about the position of equilibrium.

The more important permanent variations in the configuration of the earth's crust in the neighbourhood of the San Andreas fault in the Californian earthquake of 1906 are well shown by the model. This earthquake is regarded as an incident in the slow northward creep of the North Pacific relatively to the adjoining continents, part of the process of adjustment of the earth's crust to the interior—rendered necessary by the expansion of the crystalline rocks of the former on hydration, and the contraction of the latter as the result of cooling and loss of material by volcanic and kindred phenomena.

The President read the following communication received from Mr. S. S. Buckman, F.G.S.:—

May 29, 1910.

"In my paper on certain Jurassic Species of *Ammonites* (Quart. Journ. Geol. Soc., 1910, vol. lxvi, p. 90). I proposed for a new genus the name *Burtonia* (p. 97). With that kind helpfulness which is so distinctive of American scientific workers, Dr. W. H. Dall writes to say that this name is already in use—by Bonaparte for a bird and by Bouvignat for a naiad. I therefore desire to substitute the name *Bredyia* for *Burtonia* in my paper; *Bredyia* is from the River Bredy (pronounced 'Breedy', 'Briddy'), which flows through Burton Bradstock, and its name presumably furnishes the syllable 'Brad'. I wish to record my thanks to Dr. Dall for his kindness.

"The opportunity may be taken to rectify a misprint: in p. 68, l. 7 from the top, *for* 'striking' *read* 'sticking'."

II.—Mineralogical Society.

June 7, 1910.—Professor W. J. Lewis, F.R.S., President, in the Chair.

Arthur Russell: On the occurrence of Phenakite in Cornwall. Phenakite was unknown in the British Isles until the discovery by the author in 1905 of a single specimen at the Cheesewring Quarry, Linkinhorne, Cornwall. In 1906 he collected further specimens, showing numerous small but well-formed crystals, from a tin lode at South Phœnix Mine, Linkinhorne. In an old Cornish collection acquired by him in 1909 he found a specimen with as many as forty fine crystals; it was labelled "Topaz on Quartz from St. Agnes". Phenakite was also recognized on a specimen found about the year 1870 by Mr. J. H. Collins at South Crofty Mine, Illogan, Cornwall. Search at the Natural History Museum and the Museum of Practical Geology brought to light other specimens of phenakite placed under apatite.—Dr. G. F. H. Smith: (1) Phacolite from near Belfast. Two types were described. In the first the crystals were large (about 10–14 mm. across) and much striated, and in the second they were small (about 1–2 mm. across) but with plane faces; in both instances the crystals were twinned about the trigonal axis, the individuals interpenetrating one another, and the forms present were r $(10\bar{1}1)$, t $(31\bar{4}2)$, e $(01\bar{1}2)$, s $(02\bar{2}1)$. The measurements accord closely with the data given for chabazite. (2) The Crystalline Form of Nitrogen

Sulphide. Crystals of this rare substance have recently been prepared by Mr. F. P. Burt, University College, London, by sublimation. The constants obtained were $a : b : c = 0{\cdot}8879 : 10{\cdot}8480 : \beta = 90° 23'$, and the observed forms were (100), (010), (001), (110), ($\bar{1}$01), (011), (101), (210), (111), ($\bar{1}$21), the last four being new. The crystals were invariably characterized by polysynthetic twinning about ($\bar{1}$01). A biaxial interference figure with strong positive double refraction was visible through ($\bar{1}$01).—Dr. G. T. Prior and Dr. G. F. H. Smith: On a new Arsenate and Phosphate of Lime and Strontia from the Indian Manganese Deposits. Chemical analysis showed that the mineral approximates to the arsenic analogue of apatite. The crystals were not well formed, but the physical characters as far as they could be determined accord with those of apatite. The name fermorite, after Dr. L. L. Fermor, of the Geological Survey of India, who has made an exhaustive study of the manganese deposits, is proposed for this analogue. The presence of strontium, which has not yet been detected in apatite, is of interest.—L. J. Spencer: A (fifth) List of New Mineral Names.

CORRESPONDENCE.

A CHELONIAN FROM THE PURBECK OF SWANAGE, DORSET.

Sir,—In my article on the above subject (see Geol. Mag. for July, pp. 311–14) the following note was sent in too late for insertion:—

Hooley's *Plesiochelys vectensis* from the Wealden of the Isle of Wight (Geol. Mag., 1900, p. 263) shows a præneural and seven neurals, instead of eight neurals as suggested in the original description. The specimen probably indicates a new genus.

Seeley's *Pleurosternum typocardium*, which was insufficiently characterized in his *Index to Aves, etc., in the Cambridge Museum*, is founded on a specimen of *Glyptops ruetimeyeri*. It is much more oval in outline than my Fig. 1, a difference possibly partly due to sex, but otherwise shows no new features. The protuberances caused by the crushing through of the axillary and inguinal buttresses are quite evident. Seeley's other species, *Pleurosternum sedgwickii*, *vansittardi*, and *oweni*, appear to be typical examples of *P. bullocki*.

D. M. S. Watson.

Victoria University, Manchester.

THE TERM 'LATERITE'.

Sir,—I refuse to plead guilty to the charge advanced by Mr. Scrivenor in your July issue of attempting to force a new definition of laterite on geologists and engineers. I only ask that the word shall be employed for rocks which are chemically and physically allied to that on which it was bestowed by Buchanan.

In dealing with questions of priority of nomenclature we must inquire what was the thing (rock, mineral, or organism, as the case may be) to which the name was first applied, not why it was so applied. 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.

As a matter of fact the majority of geologists and of scientific mining engineers are now using the word in this sense, the sense which I and others are defending, and that this is so a recent discussion in the pages of the Transactions of the Institution of Mining and Metallurgy, in connexion with a paper by Mr. G. Morrow Campbell on the "Origin of Laterite", is sufficient evidence. As to the word 'bauxite' I have no objection to its being applied to a laterite exceptionally poor in silica and iron, and therefore suitable for use as a source of aluminium and its compounds, as long as it is understood that it is so employed as a commercial mineral term and not as a rock name. Scientifically, however, it should be restricted to a mineral, if such exist, in which two molecules of water are combined with one of alumina.

We shall all look with interest for the results of Mr. Scrivenor's investigation of the chemical nature of the products of tropical denudation—under whatever name or names he may describe them.

John W. Evans.

Imperial Institute.
July 1, 1910.

LATERITE AND BAUXITE.

Sir,—I am glad to learn from Mr. Crook's letter in the May number of the Geological Magazine that I am not alone in holding certain views regarding the term laterite and also the term bauxite, but it is a pity that either side should be led into criticisms that are stronger than the occasion warrants.

I can understand Mr. Crook's surprise that anyone should decline to accept, without question, the new definition of laterite, seeing by what authority it is supported, and I grant that the proposed definition is attractive. But what, in my opinion, has been lost sight of, is that laterite was defined more than a hundred years ago, and that the extension of the term in tropical countries has been based on the early descriptions, the keynotes of which are brick and iron. When an innovation is proposed—for I must with all deference ask still to be allowed to consider this 'aluminous' definition an innovation—the first question is whether it is practicable, the next whether it is necessary. I do not think the change practicable, because the ideas of brick and iron have taken firm root and have led to the term being widely used for ferruginous rocks, useful in public works and in building. As its practicability is denied there is no question of its necessity; but were the change practicable, would the new be better than the old definition? The brick and iron characteristics are easily recognized; the aluminous is not. The word 'laterite' has no etymological connexion with aluminium; it has with brick, and so, indirectly, with iron, since the setting of laterite is dependent, mainly at any rate, on the presence of ferric hydroxide. Both Dr. Evans and

Mr. Crook appear to think—I hope that I am not doing them an injustice—that because the two definitions apply to the same thing, therefore they are the same. This is hardly logical. They emphasize distinct characteristics, scientific and commercial, and are therefore different.

An example illustrating the difficulty, however, will be more to the point than a long argument. In the Federated Malay States the chief crystalline rock is granite, and the mode of weathering is excellently shown by many miles of road sections in hilly country, where the transition from fresh rock to soil can frequently be followed. The rock weathers in situ to a soft mass, red or yellow, sometimes white, in colour, in which one sees round boulders of fresh granite that has resisted decomposition and so formed 'core-boulders'. I have taken a specimen from about midway between the soil and the fresh rock, and after drying have treated it with sulphuric acid for about one hour over a water-bath. The iron and aluminium that went into solution were precipitated as hydroxides, and the aluminium hydroxide separated by KHO and re-precipitated by ammonium chloride. After ignition I obtained over 13 per cent. of alumina, and as I must assume that this alumina exists in the rock as a hydrate or hydrates, the rock falls under the proposed new definition of laterite. It is a weathering product of a crystalline rock containing aluminium hydroxides in a tropical country. But no one here calls it laterite or wishes to do so; it does not harden on exposure, and is therefore of no use as a substitute for brick. It is decomposed granite, and it would be an unnecessary complication to call it anything else, in spite of the interesting fact that a considerable percentage of aluminium hydroxide has been formed during the process of decomposition. Indeed, it may prove that this feature of tropical weathering is so general that it cannot be regarded as characteristic of any one decomposition product, and that, if the presence of aluminium hydroxides is to be the test of laterite, then there will be a difficulty in excluding rocks that have no resemblance to Buchanan's laterite, as, for instance, the china-clay and clay-slate mentioned in my last letter.

We know that the composition of laterites varies with the character of the rock from which it is derived; and I have ventured to propose that, for the sake of simplicity, we should call bauxite certain laterites in India that have been stated to be bauxite. "Laterite is bauxite in various degrees of purity." "These are bauxites in blocks and in powder." I am now told that I am guilty of endeavouring to degrade the term 'bauxite' completely, and that my suggestion is positively harmful; while I am furthermore invited to assert that a mineral of a definite chemical composition, which has not yet been proved to exist, does not exist, and to state what name I propose to give it if it should be proved to exist. The word 'bauxite', Mr. Crook says, must be reserved for a hypothetical mineral of the composition $Al_2O_3 . 2H_2O$, and it may not be used as a rock-name until that hypothetical mineral is proved to be a myth; but there is some plausibility in my suggestion because the term has been used carelessly.

Bauxite was discovered in France, and France possesses a mineralogist who cannot be accused of using mineralogical terms carelessly. In his *Minéralogie de la France et de ses Colonies*, iii, p. 342, Mons. A. Lacroix says: "Aussi me semble-t-il difficile de considérer la bauxite comme un minéral defini; il est bien plus probable que les produits désignés sous ce nom sont constitués suivant les cas par divers hydroxides d'alumine colloïdes mélangés à des hydroxides correspondants de fer et a diverses impurités, argile, sable quartzeux, etc. C'est en réalité une véritable roche." The last sentence of the above quotation makes further defence unnecessary.

This question of the use of the term 'laterite' is one in which there is abundant room for quiet discussion. My view may be extreme on the one side—indeed, is, I suppose, without question extreme in that I would like to see the term left to engineers to treat as they wish. Nevertheless, the adoption by the majority of geologists of the proposed 'aluminous' definition would not lead to a crisis, and I cannot believe that anyone or anything would suffer harm thereby. This seems to me to be an admirable opportunity for dropping the term altogether, and for substituting in its stead the term 'bauxite' when the composition justifies it; when this is not the case I would advocate the simple term 'decomposed gneiss', or whatever the rock may be, it being taken for granted that the production of aluminium hydroxides in quantity is a feature of tropical weathering.

J. B. Scrivenor.

Batu Gajah,
Federated Malay States.
June 15, 1910.

OBITUARY.

WILLIAM PHIPPS BLAKE, D.Sc., F.G.S.

Born June 1, 1826. Died — 1910.

W. P. Blake was born in New York, and educated at Yale Scientific School. In 1853 he was appointed geologist and mineralogist on the U.S. Pacific Railroad Expedition, later on he was geologist to the California State Board of Agriculture, in 1864 he became professor of mineralogy and geology in the College of California, and at the time of his death he was emeritus professor of metallurgy, geology, and mining, and director of the School of Mines in the University of Arizona. His more important papers relate to the geology and mineralogy of California and Arizona; but he had made observations on the glaciers of Alaska, on the geology of the Island of Yesso, Japan, and was the author of a volume on *The Production of the Precious Metals*, 1869 (see Geol. Mag. for 1868, p. 284, 1869, p. 361, and 1874, p. 464). He was elected a Fellow of the Geological Society of London in 1876.

MISCELLANEOUS.

Mr. H. B. Maufe, B.A., F.G.S., of the Geological Survey of Great Britain, has been appointed Director of the Geological Survey of Southern Rhodesia lately instituted by the Chartered Company.

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THE

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No. IX.—SEPTEMBER, 1910.

ORIGINAL ARTICLES.

I.—The Origin of the Nile Valley in Egypt.

By W. F. Hume, D.Sc., F.R.S.E., A.R.S.M., F.G.S., Director of the Geological Survey of Egypt.

THE article which appeared by Dr. Ball in the February number of the Geological Magazine (pp. 71–6), strongly urging the origin of the Egyptian Nile Valley as due to erosion rather than faulting, is the first public expression of a widespread feeling that the familiar rift theory is based on comparatively feeble foundations, and either requires strengthening or withdrawal. It must be remembered that when the Geological Survey of Egypt commenced its operations in 1896 the relation of deep African depressions to rifts was an accepted theory which had been found applicable in a number of striking instances. As one who has studied portions of the Nile Valley and the neighbouring deserts of Egypt for some years, I submit these few remarks, adopting a somewhat more personal point of view than is usual in papers of this nature, not from a desire for controversy, but because the subject is one worthy of discussion.

During 1896 I was in frequent correspondence with Mr. Barron regarding Egyptian geology, and from his letters it was evident that two points had impressed him, viz. the absence of sand-deposits in the Eastern Desert and the abundant evidence of faulting. The widespread nature of these fractures seemed to me open to some doubt, but the first year's work in the Eastern Desert (1897–8) led me in the main to adopt Mr. Barron's views. The magnificent dislocations in the hills opposite Qena, and gigantic slip-faulting of Arras and Abu Had, north-east of that town, were too apparent to escape even superficial observation, and the discovery of the faulted areas described by Fraas, Barron, and myself near Qosseir, helped materially to strengthen the view that faults played an important part in the structure of the country.

The investigations of 1898–9 in Sinai only tended to enhance their significance, and in a paper on the "Rift Valleys of Eastern Sinai" I pointed out that a series of parallel valleys with the younger strata faulted between the older formations could only be explained as due to fractures arranged on some systematic basis. An attempt was also made to widen this conception so as to embrace the Gulf of Suez, Nile Valley, etc.

Thus far the evidence showed that disturbances of a tectonic nature were widespread in Egypt, that they had given rise to important surface features, but at the same time the rift or trough-fault view for the Nile Valley was not gaining the required basis of fact to make its position impregnable. The highly tilted gravel ridges south of Helwan, the long ridge of Gebelain in Southern Egypt, bringing up steeply dipping Cretaceous beds, the great slip-faults of the Qena–Luxor district could be invoked, but all these manifestations of earth-movement do not fit into a regular plan of trough-faulting, and for some years my colleagues and myself had, if I mistake not, abandoned (if we ever had them) any pronounced view as to the form of the Nile Valley near Cairo being directly influenced by faults. At the same time the great differences of structure between the two sides of the Nile both near Cairo and in the Qena–Luxor reach seemed to demand some explanation, which might be of wider character than mere erosion.

Till 1900 I may frankly say that all my studies in the outer deserts of Egypt had biassed me in favour of a fault origin for the major portion of the Nile Valley; from that period onward the tide of thought took pause. Many visits to Nubia showed that faults were of minor importance there, while a study between Esna and Aswan, which was carried out on foot, every point of any interest within reasonable distance of the river being examined, further strengthened the view that in this reach of the river longitudinal faults were of no significance. On the contrary, transverse faults, such as the one at Kom Ombo, produce the most striking effects. The difference between the high Nubian Sandstone cliffs and hills on the right bank near Edfu, etc., and the comparatively low gravel ridges on the left or west bank, led to the view that the river was eroded along the original outcrop of the softer Cretaceous strata, to whose line of strike the present stream is roughly parallel. In 1906 satisfactory evidence was obtained of a transverse anticlinal roll in the hills south-east of Qena, a roll which in large measure explains the abrupt bend of the river at this point, along the outcrop of these Cretaceous beds.

This does not, however, satisfy the problem to the full; we have still to explain the remarkable ravine of the Nile between Sohag and Assiut, and the north-westward bend near Cairo. For the latter feature it seems reasonable to suggest that the river has in the main taken advantage of the more easily denuded Upper Moqattam Beds, the geology of the two banks between Cairo and the Fayum differing geologically in marked respects. As regards the straight-lined ravine of the Nile, it is of interest to note that its long axis corresponds with a synclinal arrangement of the strata, which is also the cause of the marked differences between the two sides of the Nile south of Qena. As I hope a general geological map of Egypt on a scale of 1 : 1,000,000 will appear in the course of the late summer, there will be an opportunity for all interested in the subject to weigh the evidence and form their own opinions.

The direction, therefore, in which my own views tend at the present time are put dogmatically. The southern portion of the

Egyptian Nile from Aswan to beyond Qena owes its origin to denudation of the softer Cretaceous beds, as already suggested in the *Cairo Scientific Journal.* This view is, I believe, shared by Mr. Beadnell. Owing to the temporary dominance of a transverse roll near Qena the river has turned, following the direction of outcrop of these softer strata until its further course north-westward was determined by a well-marked syncline. North of Assiut a second fold may have determined the northward deflection of the Nile, the river breaking through where the Nubian Sandstone may have had an outcrop north of the Pyramids near Abu Roash. This conception is not so imaginative as might at first sight appear, there being an exposure of Nubian Sandstone in the Abu Roash Hills close to the river-valley.[1] The slipping of heavy masses of Eocene limestone on Cretaceous shales has exaggerated the fold effects in the region between Luxor, the slip-faults being often on a gigantic scale, but these presumably cannot be regarded as evidence in favour of true trough-faulting.

So far as the Nile is concerned, therefore, I hold that folding plus erosion plus slip-faulting is sufficient to account for all the phenomena observed, a view still further emphasized by a recent visit to the desert plateau immediately north of the Qena depression. Here it is possible to study valleys in every stage of formation. The country is remarkably folded, though the individual dips seldom exceed 10°, and it is possible within a very short area to find evidence of the most varying causes of erosion. At the head of Wadi Gurdi the valley has obviously been formed along a cracked anticline; elsewhere synclinal folds have been responsible for the principal drainage-lines, whilst multiple small folds, like the waves of the sea, have determined many of the twists and turns. In addition to this complex folding, which was entirely unexpected, the rocks themselves are of a nature which specially lends itself to erosion by water. The lower part of the Eocene Series in this region is a white chalk, showing evidence of intense current-action. In these strata, caves, honeycombing of the limestone, natural bridges, and cylindrical channels, cut through the solid rock, testify to the intense activity of the erosive forces; while the deep ravines, which seam every part of this desert area, vie with the Nile Valley itself in the height of their bounding cliff-walls and the steepness of their sides. If it be remembered that the Nile Valley ravine is in its southern portion cut through these easily denuded materials, the conception of the erosion of the Nile Valley is not one which involves too great a tax on our imagination.

When, however, we consider the origin of the Gulf of Suez, I must confess that I am not prepared to go so far as my friend and colleague Dr. Ball is prepared to do. Let us grant fully the broken anticline character of the Wadi Araba area; but what does that very admission involve? Why do the Miocene beds which are found north of the northern limb of this broken anticline (the North Galala Hills) pass across into Sinai, and only reappear again in the Eastern Desert of Egypt to the south of the southern limb of

[1] See Mr. Beadnell's map of Abu Roash.

the Araba anticline, while no Miocene strata have been found in the Araba depression itself? The evidence, as I read it, points to this region having been a domed area during Miocene times, and I can conceive of no erosive agent which would break across this great earth-feature without the intervention of fracture. Be it remembered, too, that the regularity of the parallel ranges (Gebels Esh, Zeit, etc.) further south is geologically more apparent than real. In the Esh range, as I pointed out in the Eastern Desert Memoir of 1897, on the westward flank of the hills, the strata follow one another in proper succession, dipping westward as the one-half of a regular anticline. To the east of its central cone of igneous rocks what appears? Except towards the northern end of the range none of these well-developed strata (from Nubian Sandstone to and including the Lower Eocene) are anywhere present, in their place being a high-tilted Miocene coral-reef. Surely such an inequality as this cannot be lightly passed over, and until good proofs to the contrary are submitted to me I consider that faulting and faulting alone can explain the phenomena.

In Sinai the intensity of the faulting is so obvious that I await wider confirmation of its extent with equanimity, believing that the excellent effort made by Mr. Barron to unravel this most difficult problem will remain a permanent monument to his zeal and his industry. Very few would have done as much, or even a tithe as much, in the time at his disposal, and under the physical conditions which he was called upon to face. Only those who know something of the bitter cold of a Sinai winter, or the blinding sandstorms of the country between Suez and Tor, can appreciate his labours at their true value, and will be able to treat in a lenient spirit any errors of detail that may be revealed by subsequent close research in connexion with developing industries. As regards the eastern portion of Sinai, I have not one word to withdraw from the account of the rifts given in my memoir on that region, considering that the trough-fault view is the only explanation which satisfies all the conditions, geological and physical, presented by the parallel valleys of that complicated mountainous region.

The conception which seems best to satisfy all the conditions of Egyptian geology appears to involve a major north and north-westward folding which in the oases, though marked, and in the first instance originating those depressions, has nevertheless only produced fracture effects to a minor extent. (This statement is necessarily relative, for those who have read Mr. Beadnell's "An Egyptian Oasis" will remember the important fracture-line determining the line of wells in Kharga Oasis.)

In the Nile Valley *erosion* seems to have been the principal factor, the river either following the outcrops of the softer strata or the synclinal portions of the fold. The many fault-systems bordering it, especially on the east (Cairo–Suez region, Helwan area, Qena–Luxor slip-fault district, Kom Ombo plain), are not in direct relationship to the present course of the river, or in the case of the great slip-faults only appear to be so, the limestones in the cliffs bordering the Nile slipping on and crushing the Cretaceous shales underlying them.

For the Gulf of Suez, it seems difficult to explain the present conditions of its cutting through a gigantic dome, taken together with the inequilateral structure of the parallel ranges bordering the gulf, without invoking the aid of very serious fractures, whose activities are marked in most pronounced fashion on the peninsula of Sinai. Thus we have an earth wave-system gathering strength as it passes from east to west, the great trough being Egypt itself with its river in part marking the basin centre, while the wave-crest reveals itself in the serrated peaks and barren hills of the Eastern Desert and the wilderness of Sinai. Necessarily, as with the waves of the sea, this great system is broken into minor crests and hollows, domes rather than anticlines will be the rule, while curved fault-systems will surround them. All these features will no doubt become more and more marked as the detailed geological structure demands attention from economic or other reasons. In Sinai the north-west trend of the waves is replaced by a dominant north-eastward direction, but we know far too little of Northern Arabia to dogmatize as to its meaning and significance. A second, or transverse system of folds, is no doubt of great importance, and its true meaning will become more obvious as study proceeds, but as this involves work in regions difficult of access, or complicated in outline, progress will necessarily be slow, nor do these earth-movements bear prominently on the question.

Briefly summarizing the point of view I at present hold—

1. The main structure of Egypt is determined by two major fold-systems, one having dominant north or north-west trend, the other more or less transverse to this system.

2. In the north-trending fold-system the wave-crests and troughs become more pronounced from west to east, finally resulting in fractures of the greatest geographical importance.

3. In the depression containing the oases, comparatively gentle folding has resulted in the denudation of those portions where the anticlinal structure is most pronounced, fracture being unimportant as regards surface-features, though in Kharga of great moment for water-supply.

4. The Nile Valley is regarded as due in the main to the combination of the north-trending fold, erosion of the softer Cretaceous strata in the south of Egypt, and the less resistant members of the Middle Eocene in Northern Egypt, the connecting Nile ravine following the axial line of the centre of the synclinal trough.

5. The Gulf of Suez, though in direction determined by the dominant fold-trend, has required fracture for its full formation, there being possibly a minor fold region due to such fracturing between the Red Sea Hills and the main range of Sinai.

6. In Sinai itself the fold-trend swings from north-west to north-eastward, and fracture-lines almost completely mask the original folds, which are only indicated by the trends of the gulfs and their parallel valleys.

II.—Notes on new or imperfectly known Chalk Polyzoa.

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

(PLATE XXX.)

(*Continued from the June Number*, p. 260.)

Rhagasostoma Novaki, nom. nov.

Syn. *Membranipora depressa*, Novak, Denkschr. d. kais. Ak. d. Wiss. zu Wien, Math.-Naturw. Cl., Bd. xxxvii, p. 88, Taf. ii, figs. 9, 10.

Novak considered this form within the range of variation of *Cellepora depressa*, Hag., but Canu[1] recognizes it as a *Rhagasostoma*. It appears to be so closely related to a very distinct and persistent form which is very abundant and characteristic at Trimingham that I do not like to treat them as anything but two forms of a single hitherto unnamed species, and the form admirably figured by Novak must of course be the type of the species.

Rhagasostoma Novaki, mihi, var. Anglica, nov. Pl. XXX, Fig. 1.

This is the above-mentioned form from Trimingham. It is distinguished from Novak's type by the squareness of the aperture, the much greater depth of the sinuses, and the general prevalence of a distinct inflexion of the sides of the aperture which makes the sinuses slightly bottle-shaped. The avicularia often show an interesting structure which would no doubt be found also in perfect specimens of Novak's form; the sinus at the lower end of the aperture is closed by a narrow rectangular projection into the aperture just wide enough to seal up the sinus, and which is so deep-set as to appear to be not so much a process of the edge of the front wall as attached to its under surface.

Very abundant at Trimingham; one specimen in zone of *B. mucronata*, Isle of Wight.

Cribrilina claviceps, nov. Pl. XXX, Figs. 2–5.

Zoarium always adherent.

Zoœcia very variable in size, length ·68–·9 mm., breadth ·35–·5 mm.; aperture variable in length and breadth, shaped like a keyhole, with a thickened margin round the upper part; what appear to be calcareous opercula may be sometimes seen inside the zoœcia or even (Fig. 4) in situ; a pair of perforate tubercles often possessing a slight beak occur very regularly beside the aperture, and others occur somewhat irregularly on the edges of the front wall; front wall slightly but decidedly keeled (Fig. 4), and showing six or seven pairs of faint radiating imperforate furrows.

Oœcia not observed.

Avicularia not observed except so far as the tubercles may be avicularian.

Occurs regularly but sparingly in the *M. cor-anguinum* zone at Gravesend and in Hants, and in the *Marsupites* zone in Hants.

[1] Bull. Soc. Géol. France, 1900, p. 428.

CRIBRILINA FURCIFERA, nov. Pl. XXX, Figs. 6–8.

Zoarium always adherent.

Zoœcia very variable in size, length ·5–·7 mm., breadth ·4–·58 mm.; aperture semicircular, with a stout perforated tubercle on either side, and generally two, sometimes three, and rarely four more slender perforated tubercles between them round the upper lip; the lower lip is much thickened, especially down the centre of the zoœcium; its upper edge is primarily straight, but frequently develops a stout forked projection, the arms of which reach to a point where they partly overhang and appear to rest on, but do not in fact touch, the stout paired tubercles; at other times it develops a blunt denticle only; front wall generally highly arched, but varies down to almost flat as in Fig. 8, and covered with radiating ribs varying from very fine and numerous as in Fig. 6, to stout and few as in Fig. 8, the normal type with fairly fine and numerous ribs, only clearly distinguishable round the margins, being represented by Fig. 7; the furrows between the ribs are only perforated once, at their outer extremity. The side walls of those zoœcia in which alone they are visible, i.e. those at the edge of the zoarium, are rather splayed and have large foramina in them, one of which, at the extreme upper end of the zoœcium, is quite invariable in its occurrence.

Oœcia very large in proportion to the zoœcium, of the globose type, but with a tendency to become slightly pointed, and with a strongly recurved free edge; they arise just above the pair of stout tubercles, but envelop the others.

Avicularia. Small, depressed, slightly conical cells of irregular outline, with a sub-central rounded aperture and one or two large foramina in the front wall, such as may be seen in Fig. 8, occur sparingly but persistently, and may be in the nature of vicarious avicularia.

This species is not uncommon in the *M. cor-anguinum* and *Marsupites* zones of Kent and Hants, is common in the *Act. quadratus* zone of Hants and Sussex, and occurs also in the *B. mucronata* zone of Hants.

CRIBRILINA FILLIOZATI, nov. Pl. XXX, Figs. 9 and 10.

Zoarium always adherent, resembling that of *C. furcifera*.

Zoœcia small, length ·58–·72 mm., breadth ·4–·5 mm.; aperture circular, but with the lower one-fourth of its circumference cut very sharply back so as to include an arc of a slightly larger circle; front wall gently arched, almost smooth, the radiating ribs and furrows which fix the generic position being almost obliterated; the outside zoœcia show very regularly a large foramen almost at the head on the sloping surface above the aperture.

Oœcia very large, strongly resembling those of *C. furcifera*, but relatively rather longer and narrower, and with a stronger tendency to be pointed.

Avicularia not observed.

Occurs sparingly in the *Act. quadratus* zone in Hants.

It will be observed that the last three species are none of them typical *Cribrilinæ*, and in two of them the furrows are wholly imperforate. At the same time their front walls are obviously of Cribrilinid type, i.e. built up from marginal spines more or less fused together, and it seems to me, as indicated at p. 292 of the volume of this Magazine for 1906, that in the Chalk it is not feasible to maintain one particular stage in the lateral fusion of spines as a separate genus *Cribrilina*, and that that genus must be enlarged to comprise all stages of lateral fusion short of total obliteration of the spinous origin. The only alternative would be to create a new genus for all stages of lateral fusion except *Cribrilina*, as usually defined; such a genus would not admit of a positive definition, and is obviously undesirable.

EXPLANATION OF PLATE XXX.

Fig. 1. *Rhagasostoma Novaki*, var. *Anglica*. Trimingham. × 12 diam.
,, 2. *Cribrilina claviceps*. Gravesend, Kent. × 12 diam.
,, 3. Ditto, the same specimen. × 21 diam.
,, 4. Ditto. Whitchurch, Hants. × 12 diam.
,, 5. Ditto. Gravesend. × 12 diam.
,, 6. *Cribrilina furcifera*. Andover, Hants. × 12 diam.
,, 7. Ditto. Bramford, Suffolk. × 12 diam.
,, 8. Ditto. Kingsgate, Kent. × 12 diam.
,, 9. *Cribrilina Filliozati*. Andover, Hants. × 12 diam.
,, 10. Ditto. West Tytherley, Hants. × 21 diam.

(*To be continued.*)

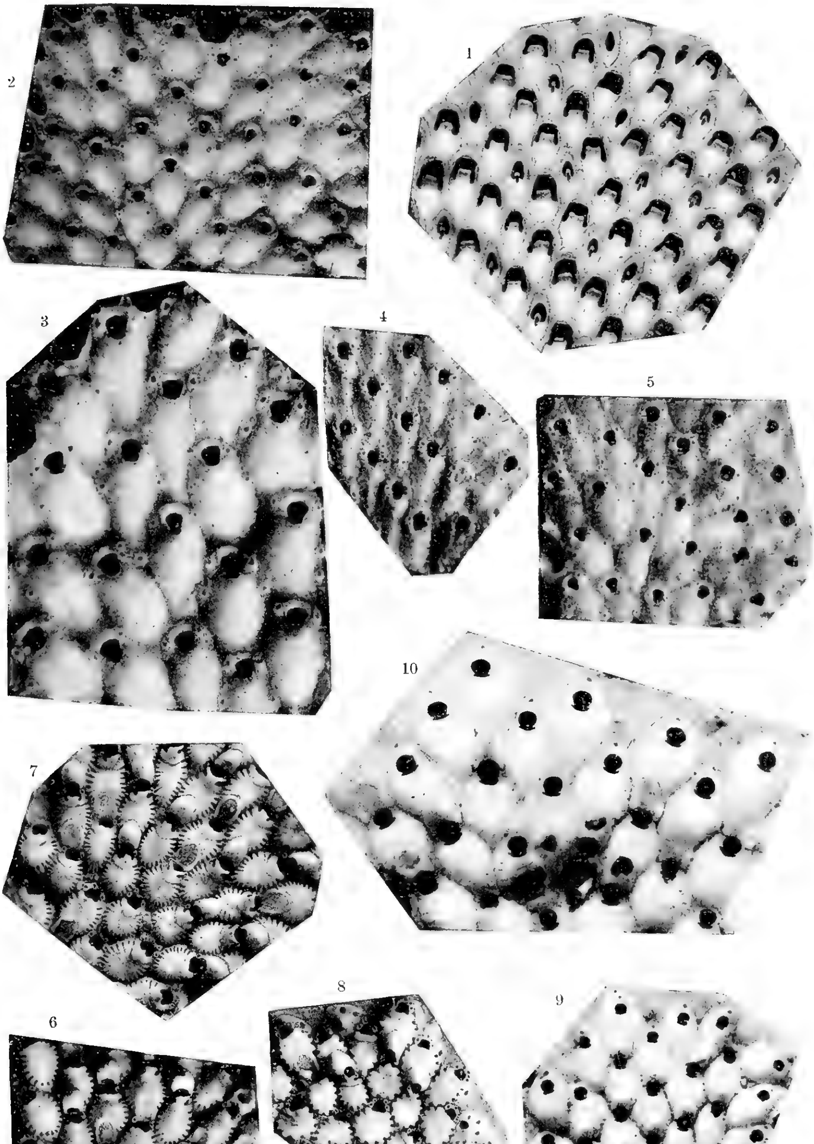
III.—The Fissure Theory of Volcanoes.

By Professor E. H. L. Schwarz, A.R.C.S., F.G.S., Rhodes University College, Grahamstown.

Dr. Hans Reck has adduced an example of a volcano which, according to him, has been formed independently of a fissure. The volcano pierces the centre of a faulted block, the Herdubreid, in Iceland, and on the vertical fault-faces there is no sign of any fissure.[1] The example is probably unique in the world, and seems at first sight to negative the hypothesis that the escape of gases which tear through the earth's crust and form the chimneys of volcanoes is in the first place initiated by a fracture; on closer examination, however, the fact that the volcano stands in close relation to the faults which bound the horst, and the many cases which are known to occur where a fracture in the earth's crust may be healed at the surface so that the rocks about the fracture are subsequently more resistant than before, seem to point to the Herdubreid volcano being a normal fissure-formed volcano, only that it stands in the same relation to the fracture as a parasitic cone stands to the central crater. In other words, the chimney is an escape vent leading below the surface to one of the bounding faults of the horst.

The Herdubreid is a part of the north and south range of mountains made of palagonite tuff, which sinks towards the north below the level of the Odadahraun lava plateau, some 600 metres above sea-level, and on the south rises to 1077 metres. The Herdubreid is 1200 metres high, and is separated from the main range by a gorge

[1] Hans Reck, "Ein Beitrag zur Spaltenfrage der Vulkane": Centralblatt für Min., Geol., u. Palaeont., 1910, No. 6, p. 166.



R. M. Brydone, Photo. *Bemrose, Collo.*

Chalk Polyzoa.

500 metres wide; its walls are vertical, but the lower parts are hidden by debris. The square summit rises gradually to the crater, with its lavas of much more recent date than the palagonite tuff. The sub-structure of the volcano is shown in the four bounding fault-faces to a height of 700–800 metres above the accumulations of debris. On the north side there is a horizontal line where a darker and lighter material in the tuff meet; the whole length of the line is exposed, and there is no trace of a dislocation. The material forming the basement of the horst is quite fresh on the exposed side, since the outer surface is rapidly weathering under the influence of frost, and the weathered material is removed by wind; this applies to all the four sides of the block, so that from all sides the evidence of the want of a fissure is perfectly clear. Dr. Reck concludes his article with the statement—It is therefore proved from observation that in one case at least a fissure does not extend under the basement of a volcano for a depth of from 300 to 400 metres.

One of the best examples I know where a fracture in the earth's crust has been healed is in the Berg River Hoek, near Paal in Cape Colony. I was called in to report on the nature of the valley with regard to its being suitable for a large reservoir. The site of the proposed retaining wall was traversed by a great fracture, on either side of which the rock, quartzite belonging to the Table Mountain Series, had been brecciated for 3 or 4 yards. I investigated the fracture very fully and found that the crush-breccia, through cementation by secondary silica, had not only become very much more compact than the quartzite itself, but that the uncrushed rock beyond the crush-breccia had been also hardened by the deposition of secondary silica. The whole zone in the neighbourhood of the fracture was eminently suitable for the foundation of a retaining wall; not only so, but the cementing of the neighbouring rock showed that subsequent movement would not take place along the old fracture, but would have to find relief some distance away.

Dr. Reck admits that all the volcanic fissures of the North of Iceland lie in a north and south direction, parallel to two of the bounding faults of the Herdubreid horst, so that it is at least admissible to those who believe in the fissure theory of the origin of volcanoes to consider the Herdubreid chimney to be an offshoot of a volcanic fissure, the surface end of which has been closed by cementation.

Daubrée's experiments on the exploding of dynamite in steel shells shows us how a fissure may allow the escape of gases, and that these in tearing their way to the surface may drill cylindrical holes; the minute fracture in the case of the shells need not have extended to the surface. I have in mind, however, what I have termed a fossil earth-quake, where a spherical mass of dolerite has been shot off from a horizontal sheet of that rock and has drilled a hole vertically through the overlying shale for a height of 15 feet. The example is at Cradock in Cape Colony. The cause for the ejection was probably that the molten rock encountered a reservoir of water, and in the explosion which followed a portion of the dolerite was projected upwards. The space where the projected mass of rock once was, and the path of the projectile, are filled with crushed-up shale. I call it a fossil earthquake because the jar the explosion must have given to the earth's crust must have produced a quite appreciable earthquake at the time of its occurrence, but in the present instance it is interesting as an example where a perfectly circular vent may be drilled through the rocks by means of the eruption of volcanic material without a fracture, but this only occurs where the molten rocks come sufficiently near the surface of the earth's crust to allow the explosion of gases. The Cradock fossil earthquake is in direct connexion with a fissure filled with dolerite which was once molten, so it seems to me probable that the Herdubreid volcano likewise is connected with a volcanic fissure rather than that it should have pierced the whole thickness of the solid earth's crust down to where some reservoir of molten material might have existed.

IV.—On the Formation of Dreikante in Desert Regions.

By A. Wade, B.Sc., A.R.C.S., F.G.S.

(PLATES XXXI AND XXXII.)

When one considers the part Britons have played in exploring and investigating the various desert regions of the world, one is surprised at the relatively small amount of literature that there is in the English language dealing with the phenomena which are peculiar to desert conditions. Many hazy, and even erroneous, ideas are still held with regard to the processes at work and the effects produced by the various agents of denudation.

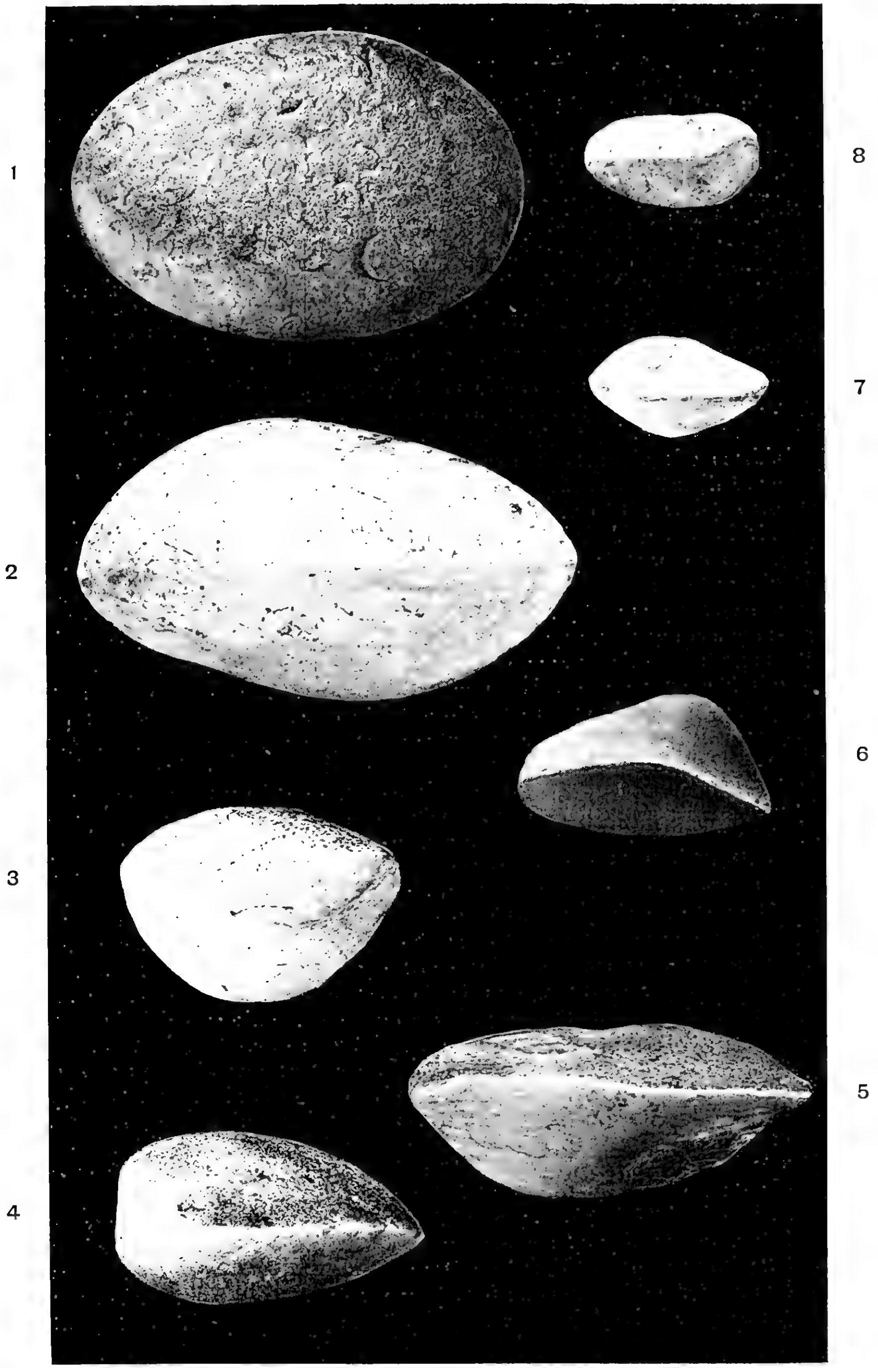
The three-edged stones known as 'dreikante', which are so characteristic and abundant in most desert regions, have been subjected to little careful investigation whilst in actual process of formation, and many ideas which appear to be incorrect are current with regard to their mode of origin.

Originally it was thought that they had been cut by river action, or by the movements of sand in the beds of rivers. Steenstrup proved that this was impossible,[1] and it is now known that they are essentially the products of wind-blown sand. In shape they usually resemble very closely a Brazil nut, and it is commonly thought that this characteristic form is produced as follows.

Fig. 1.

The travelling sand-grains strike a stone or a pebble lying on the desert. They are in consequence divided into two streams which pass along the sides of the object, wearing away the sides and producing a pointed snout to the pebble and a sharp ridge along the crest. (See Text-fig. 1.) It is difficult to see, however, why the ridge should remain equally sharp from front to back, and why the end

[1] *Geol. Fören. Stockholm*, x, p. 485; xiv, p. 493.



Pebbles from the Eastern Desert of Egypt, showing the gradual evolution of the 'dreikante' by the abrasive action of wind-blown sand from the earlier stages to the last.

opposite to the point from which the wind usually comes should be just as pointed as the other. It is inconceivable that the deflected currents of sand-grains would keep so closely to the pebble from end to end. One would expect a pointed front and a more or less unworn end. This, however, does not occur. It seems therefore that this explanation is not quite satisfactory in its nature.

During 1909 I spent a good many months on the Eastern Desert of Egypt, and it occurred to me to make a careful examination of the dreikante, which are so abundant in the stony desert tract which stretches between the Red Sea Hills and the coast.

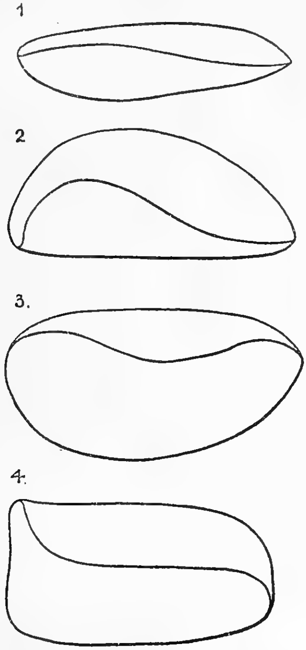


Fig. 2.

Fig. 2. Types of ridge-curves in dreikante shown in plan. The type figured in No. 3 is often so modified at each extremity by branching that instead of having two upper faces the dreikante has four.

The dreikante are usually formed from quartz pebbles derived from the Nubian Sandstone, but flints from the Eocene, granites and porphyries from the mountains, and some dolomitic limestone also furnish supplies. The most perfect examples are produced from the quartz pebbles and from a fine-grained red felsite.

The locality is almost an ideal one for such an investigation, since the wind blows almost invariably from one quarter (north, or a little west of north). At the outset I was struck by the fact that the long axes of the dreikante were not usually set in the direction of the prevailing wind. This led me to work carefully and systematically over a limited area. I marked out a portion of fairly level desert, something under half a square mile in extent, and noted with regard to all the dreikante I could find exactly how they were situated with regard to the wind. I noted between 300 and 400 specimens, and found that 78 per cent. were set approximately at right angles to the direction of the prevailing wind, whilst only 22 per cent. were set approximately parallel to that direction. Evidently the theory already stated will not account for these facts. Moreover, not all the wind-worn pebbles were three-edged, though there seems to be a tendency towards the Brazil-nut shape in the late stage of erosion in all cases.

Stones were found in all stages, from the well-rounded, water-worn pebbles from the Nubian Sandstone (Pl. XXXI, Fig. 1), or angular flints and broken pieces of igneous rock, showing only incipient traces of the abrasive action of the wind-blown sand, to dreikante, worn down until almost level with the surface of the desert (Pl. XXXI, Figs. 7 and 8). The series shown in Pl. XXXI, Figs. 1–8, gives an almost complete 'life' history of the dreikante from the earlier stages to the last.

The ridge along the crest is rarely a straight line, but is more usually a more or less delicate curve. In the Text-figure (Fig. 2) Nos. 1 and 2 are the more usual types of curve. The side of the stone facing the wind is always beautifully smoothed and polished, presenting a clean, fresh surface to the wind. Frequently this face is the only one showing signs of cutting by the sand, the remainder of the pebble showing the original water-rounding, and is also usually stained, probably with iron oxide. This shows that in such cases the pebble has not been moved by the wind since it was exposed to the action of blowing sand, for if such had been the case other faces would have been cut upon it. Such pebbles usually present a ridge-line like Text-fig. 2, Nos. 3 or 4.

The face presented to the wind is not a plane surface, but is also gently curved. Measurements taken from over fifty specimens showed that this surface makes an angle with the vertical which varies between 40° and 50°. It most usually approximates to 45°. The curve is shown in Text-fig. 2, No. 4.

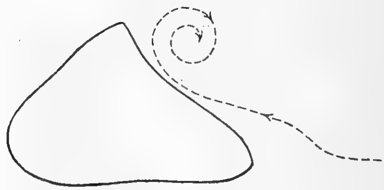


Fig. 3.

We are now in a position to consider how the dreikante have been formed. Evidently in most cases the travelling sand-grains do not, on encountering a pebble, split into two currents which travel along the sides of the stone and so form a ridge. Instead of this they tend to move upwards over the pebble with an eddying motion. The curve produced nearest the ground is always convex towards the wind.

'Dreikante,' showing beautiful wind-cut curves: Eastern Desert of Egypt.

(See Text-fig. 3.) This is probably explained by a zone of compression in the air at this point causing most of the grains to rise a little before they would otherwise do so. They apparently glide upwards over this zone in a path which is convex towards the wind. The action of the wind drives them forward against the face of the stone from which they rebound, describing what appear to be parabolic curves. The large dreikante shown in Plate XXXII is an excellent example, showing beautiful wind-cut curves.

It seemed to me that from a measurement of these curves one might be able to deduce some law with regard to the action taking place. I attempted the task, but though I was able to prove that they were parabolic, I was unable to obtain any good result, probably owing to the inaccuracy of my methods in transferring the curves on the faces of the stones to paper. This proved to be a task requiring very delicate instruments. There seemed, however, to be some similarity between the curves from the faces of different specimens, and it should be possible, I think, to obtain from them a measure of the velocity of the wind and the energy expended in erosion. The presence of stones and pebbles near to one another cause various modifications of the simple case. Side currents, eddies from other stones, all produce these effects, and these can be traced on the dreikante under consideration when examined in situ.

But how are we to explain the Brazil-nut shape? The cutting away of one face only is not enough to do that. The cutting away, however, continues until the pebble stands on a very narrow base in almost unstable equilibrium. A little extra wind and it is blown over, and the cutting commences again on a fresh side. Evidences of this are quite common on the desert. Sometimes at night the rattling of the pebbles moving under the action of a high wind is very considerable. The five-faced pebble shown in plan in Text-fig. 4 could not be explained by the earlier theory. It was originally a partly developed dreikante which has been twisted at right angles to its original direction and the abrasive action continued.

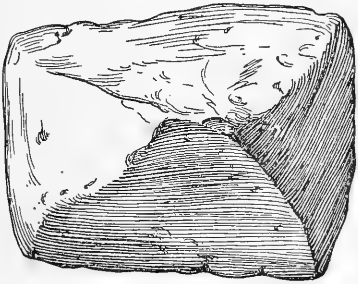


Fig. 4.

Most of the well-developed dreikante show a kind of spiral twist in the direction of their long axis. This appears to show that the path of a particle in a wind eddy is not a very simple curve. There are a good many curiosities in the formation of dreikante which are certainly produced by the action of eddies. They would probably produce interesting results when studied by a well-trained physicist on the spot. The last stage in the formation of dreikante is reached when the pebble is reduced to an almost flattened little plate, which is sooner or later reduced in size to a mere sand-grain. Again, one can observe this reduction in all stages on the desert. Actual experiment with laboratory conditions proved that these three-edged stones could not remain with their pointed ends facing a strong air current, but that they invariably tended to set themselves broadside on towards it. This is consistent with the explanations given above, and to some extent confirms them.

The following short bibliography will perhaps be useful to those who are interested in these and other kindred phenomena:—

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See also F. A. Bather, "A wind-worn Pebble in Boulder-clay," Geol. Mag., 1905, p. 358; and "Wind-worn Pebbles in the British Isles, etc.", Proc. Geol. Assoc., vol. xvi, pp. 396–420, pl. xi, 1900 (with references to eighty-seven papers on dreikante and other wind-polished stones).

V.—On some supposed *Pholas*-borings from the Shores of Birket el Qurûn, the ancient Lake Moeris, of the Fayûm, Egypt.

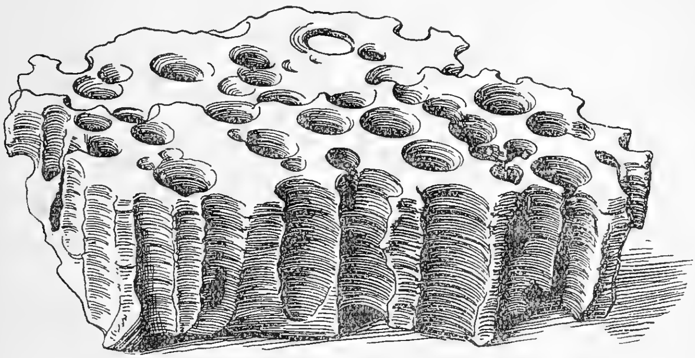
By Henry Woodward, LL.D., F.R.S.

In a review of Mr. H. J. L. Beadnell's important Memoir on the Topography and Geology of the Fayûm Province of Egypt, published by the Egyptian Geological Survey in 1905,[1] I briefly referred in passing to some "curious blocks of sandstone, pierced by numerous borings", described by the author, and I added, "they appear to be the exact replica of specimens brought home from Lake Tanganyika by Mr. J. E. S. Moore" (p. 519).

Mr. Beadnell writes in his memoir at p. 71—"*Borings on Rock-surfaces; of doubtful age.* There are within the Fayûm depression numerous rock-surfaces pierced by borings, apparently the work of marine boring mollusca but naturally offering no exact evidence as to their age and origin. These borings are found at two distinct levels, approximately from zero to 20 metres above sea-level and at 112 metres above sea-level.

[1] See Geol. Mag., 1905, pp. 516–19.

"(*a*) *Low-level borings.* Between Tamia and Dimê, near the eastern end of the Birket el Qurûn, the lowest ground, consisting of poor sandy land with tamarisk scrub, bordering the lake and cultivation [the lake] is bounded by a low escarpment of beds of the Birket el Qurûn Series. Along certain horizons one or more beds of calcareous sandstone weather into large globular masses, which, as already pointed out, are in reality huge concretions,[1] but which may have been further rounded by water action. The chief point is, however, the fact that these blocks are honeycombed in the most remarkable way by beautiful examples of borings; their presence was first noticed by Schweinfurth. The globular masses of sandstone, often several feet in diameter, are worn on the surface into a number of parallel ledges, each of which is perforated by countless numbers of *vertical holes*, averaging 10 mm. in diameter (maximum 15 mm.), placed at right angles to the ledges; these holes are not, as a rule, connected from one ledge to another. They occur in every stage of perfection, from hollows as small as the finger-tips and only a few millimetres deep to long complete chambers which generally show considerable tapering, and are often placed so close together that the dividing wall is pierced [see woodcut].



"Block of sandstone pierced by numerous borings," reproduced from Mr. H. J. L. Beadnell's Topography and Geology of the Fayûm Province of Egypt (Cairo, 1905), p. 72, fig. 7.

"At El Kenîsa, a promontory jutting out into the lake, sandstones showing shell-borings occur at a height of 14 metres above sea-level. Between Dimê and the lake a calcareous sandstone contains many borings, 66 metres above the lake-level or about 22 metres above sea-level.

"(*b*) *High-level borings.* Further west, but at a considerably higher level, borings are again met with. In this case a hard compact limestone, forming a dip-slope surface on the top of the lower cliff of the Qasr el Sagha Series, was found pierced with borings, similar in character to those of the lower level. The exact locality where these high-level borings were observed is 14 kilometres west of the western end of the lake and 16 kilometres north-east of the eastern extremity

[1] See *infra*, p. 401.

of Gar el Gehannem. The height was determined as 156 metres above the Birket el Qurûn, or 112 metres above sea-level, and we have every reason to believe these figures to be approximately correct. Up to the present time borings at this altitude have not been met with in any other locality."

In Mr. J. E. S. Moore's book *To the Mountains of the Moon*, Tanganyika Expedition, 1899–1900 (published 1901), p. 160, the author writes—"The water's edge [of Lake Kivu] is generally fringed with bushes and *tall reeds*, which grow thickly together, and the land rises so steeply into the grass slopes behind that it is exceedingly difficult to get on shore at all from a boat. In consequence of this peculiar character of the shores there are hardly any places where there are sand-beaches or rocks, and it was only after I had been paddling about for an hour, and scanning the innumerable islands with my glasses, that I saw a low rocky shore on the left, on which I landed. It was a most extraordinary place, backed up by a steep green hill. The rocks which I had seen consisted of strange rounded masses like the surface of a pudding, and, wherever they were wet by the ripples of the lake, were covered with green *Cladophora* and slime, and in places they rose up into weird stony trunks, like those on the old coral beaches one sees about Mozambique. These upstanding lumps were, moreover, *pierced with holes*, as if they had been prepared for blasting operations, and for the life of me I could not find out for a long time what they were or how they had been formed. When I broke off a portion, moreover, I found to my intense surprise that the stone was full of fossil shells; there was an unmistakable *planorbis* and some conical forms, probably *melanias.* But what animal had bored the *long straight holes*, about an inch in diameter, which ran parallely through the mass? I could not make this out, but after a time I found one mass with an old partially fossilized reed-stem filling up one of the holes, and then the mystery was suddenly solved. The holes were the casts, in a lake deposit of some kind, of reeds that had once grown there. That this was so soon became certain, for I found several clumps of old dead reed-stems already becoming covered up with a curious incrustation from the waters of the lake which forms about them, and other similar structures. In other places this substance, which turns out to have a high percentage of carbonate of magnesium, binds the loose pebbles of the shore into masses of conglomerate, which are as hard as if they had been made of Roman cement" (p. 160).

Having been so fortunate as to have seen and examined the specimen sent home by Mr. Beadnell and figured above, and also the hand-specimen from Lake Tanganyika obtained by Mr. Moore, I may venture to pronounce upon the identity in their character, and to express the opinion that the perforated blocks from the Fayûm are not the work of boring mollusca in rock, but that the sandy calcareous material, which is similar to that from Lake Tanganyika, has been accumulated around the stems of reed-like water-plants as a more or less concretionary deposit precipitated from the waters of the present lake or from those of its more extensive predecessor, Lake Moeris, around the shores of which grew in abundance large clumps of these tall reeds with hard siliceous stems,[1] the final decay of whose upright stems have left the hollow cylindrical cavities which suggested to my friend, Mr. Beadnell, the resemblance to the crypts of boring Mollusca.

Dr. C. W. Andrews, F.R.S., who has paid several visits to the Fayûm in search of fossil mammalia, informs me that the tall *Arundo*-like reeds always grow in large clumps along the margin of the lake, and 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.

He suggests that the accumulation which had been originally formed in the interstices between and around their thickly growing reed-like stems, was largely composed of the fine grains of sand-dust blown by the prevailing winds, and which had since become solidified into a concretionary sandstone by the addition of calcareous and saline matter contributed by the waters of the lake itself.

On this point Mr. Beadnell observes (p. 13, op. cit.): "Although under the present desert conditions practically no material from the surrounding desert is washed into the lake, doubtless a considerable amount of fine dust and sand is carried into it by the wind, especially during the violent sandstorms which occur frequently in the locality. The high cliffs which bound the northern shore of the lake, throughout a portion of its length, probably have the effect of checking the velocity of both north and south winds, thus causing a considerable amount of sand, which would otherwise be carried across, to be dropped on its surface" (p. 14).

The occurrence of these globular masses of concretionary sandstone, perforated by countless numbers of vertical holes, at different levels, both at and above the present margin of the lake, is readily explained as being due to the gradual shrinkage of the level of the lake,[2] which is constantly going on from evaporation and supposed underground outlets, and this, together with the quantity of water absorbed by the large area (1800 kilometres) under cultivation in the Fayûm, is probably in excess of that received by the Bahr Yusef Canal, the natural inlet from the Nile.

The vast proportion of perforations made by *Saxicava* and by *Lithodomi* generally, penetrate the rock in all directions, and offer no very close analogy to these usually straight, tubular, parallel, closely arranged hollows.

But the crypts of *Pholas crispata* are at times more regular, often forming extensive colonies, and the animals, in burrowing, less seldom invade one another's retreats. They commence as quite small crypts, but as the mollusc increases in size and the perforation deepens, it expands its chamber *laterally*, which, seen in vertical section, becomes somewhat flask-shaped with a slender neck. The lower end is rounded and has the largest diameter. Should the boring mollusc pass through the ledge and so expose the lower extremity of the

[1] See pl. xvi. View near the western end of the Birket el Qurûn, also view of the north side looking west, pl. i, in Mr. Beadnell's Memoir on the Topography and Geology of the Fayûm Province of Egypt (Cairo, 1905).

[2] Now occupying only 225 square kilometres, the whole area of the Fayûm depression, much of which was once a lake, covering about 12,000 square kilometres.

animal, it pays the penalty with its life. Most of the perforated blocks from the Fayûm show the burrows passing completely through the masses.

Pholades generally occur *between tides* from high to low water. Their burrows always hold sea-water, which is renewed with each tide. The *Pholas* is assisted by the grains of sand brought by each tide to bore downwards into the rock with its foot and so deepen its burrow. It is most improbable that *Pholades* could exist in a lake, however salt, as they require tidal action to carry on their existence. Mr. Beadnell writes, op. cit., p. 14: "The phenomenon of the extraordinary freshness of the Birket el Qurûn has been commented on by Schweinfurth, who shows that the degree of concentration of salt in a lake whose volume has been continually reduced, and to which salt has constantly been added, should be many times greater than the actual existing amount." An analysis [1] of the water at the west end of the lake (where the concentration is greatest, owing to the distance from the feeder canals) showed that the total salts amounted to only 1·34 per cent., of which 0·92 per cent. was sodium chloride.

VI.—On a Fossil Sole and a Fossil Eel from the Eocene of Egypt.

By Arthur Smith Woodward, LL.D., F.R.S., of the British Museum (Natural History).

(PLATE XXXIII.)

TWO well-preserved Teleostean fishes from the Eocene Limestone of Tura, between Heluan and Cairo,[2] have been submitted to me by Dr. W. F. Hume, Director of the Geological Survey of Egypt. They apparently represent new species, but, like most fishes of Eocene age, they are remarkably modern in type, and one seems to be referable to an existing genus. With them were found remains of two species of Percoid fishes, which are scarcely sufficient for exact determination.

1. Solea eocenica, sp. nov. Pl. XXXIII, Figs. 1, 1*a*, *b*.

A small fish measuring 5·7 cm. in total length is a true Pleuronectid, and may be compared with the diminutive species of *Solea*, already known from the Lower Miocene of Würtemberg.[3] As shown by Pl. XXXIII, Fig. 1, the upper part of the anterior half of the specimen is broken away, but otherwise it is completely exhibited in direct left side view.

The head with opercular apparatus occupies somewhat less than one-quarter of the total length to the base of the caudal fin. The maximum depth of the trunk must have equalled slightly less than half of this total length. Some of the head-bones are distinct and

[1] *A Preliminary Investigation of the Soil and Water of the Fayûm Province*, by A. Lucas, Survey Department, Cairo, 1902.

[2] W. F. Hume, "The Building Stones of Cairo Neighbourhood and Upper Egypt": Geol. Surv. Egypt, 1910, p. 44.

[3] *Solea kirchbergana*, H. von Meyer: *Palæontographica*, 1851, vol. ii, p. 102, pl. xvii, figs. 2, 3; also loc. cit., 1856, vol. vi, p. 25, pl. i, fig. 3.

can be readily identified (Fig. 1*a*). Below the base of the skull (*c.*) the pterygo-quadrate arcade is seen, the ectopterygoid having a thickened and sharply bent oral margin, and the relatively large quadrate (*qu.*) inclined forwards. The long and gently arched maxilla (*mx.*) has a large articular head in front and is slightly expanded at its hinder end. The slender, parallel premaxilla (*pmx.*) completely excludes this bone from the margin of the mouth. The mandibular ramus is short and deep, triangular in shape, with the dentary (*d.*) and articulo-angular (*ag.*) taking about equal shares in its constitution. The only teeth clearly distinguishable are very minute points on the oral border of the dentary. The pre-operculum (*pop.*) is sharply bent, with the upper and lower limbs of equal size, each tapering to a point. Its hinder border is rounded at the angle, and its smooth outer face is marked with four large openings into the slime-canal. The small operculum and sub-operculum are somewhat displaced, and there are traces of about six branchiostegal rays below. Nine vertebræ can be counted in the abdominal region, and two of the centra exhibit the lateral median longitudinal ridge. The minute ribs cannot be seen, but the large hypapophyses are conspicuous below the six posterior centra, slightly increasing in size backwards. There are twenty-two caudal vertebræ, and the neural and hæmal arches are long and slender. The hindmost caudal centrum bears the complex of hæmal and neural arches for the support of the caudal fin shown in Fig. 1*b*. The long and slender left clavicle is well seen (Fig. 1*a*, *cl.*), bent forwards at its upper end, slightly expanded below, and there are traces of the pair of small rod-shaped pelvic fin-supports (*plv.*) among the scales postero-inferiorly. The rays of the paired fins are not recognizable with certainty, but the anal and caudal are well displayed, and the hinder part of the dorsal is also seen. The rays of the anal and dorsal fins are remarkably slender, and those of the anal are thirty-six or thirty-seven in number. The foremost anal fin-support is a long curved bone forming the hinder border of the abdominal cavity. The caudal fin, which is rounded, comprises about eighteen rays, of which the first three at the origin above and below are short and comparatively stout, closely adpressed and gradually increasing in length. The principal caudal fin-rays are distantly articulated and bifurcate distally. The trunk is completely covered with a dense squamation, which seems to extend slightly over the base of the dorsal and anal fins. Though not easily observable, the scales are evidently antero-posteriorly elongated, and there are sometimes traces of a fringe of slender denticulations at their hinder border.

As already suggested, the fish now described is most closely similar to the small *Solea kirchbergana* from the Lower Miocene of Würtemberg, and, like that species, it appears to differ only from the typical existing *Solea* in the comparative shortness of its caudal region. In the latter respect it corresponds with the allied existing genus *Achirus*, which has curiously modified pelvic fins.[1] As, however, the

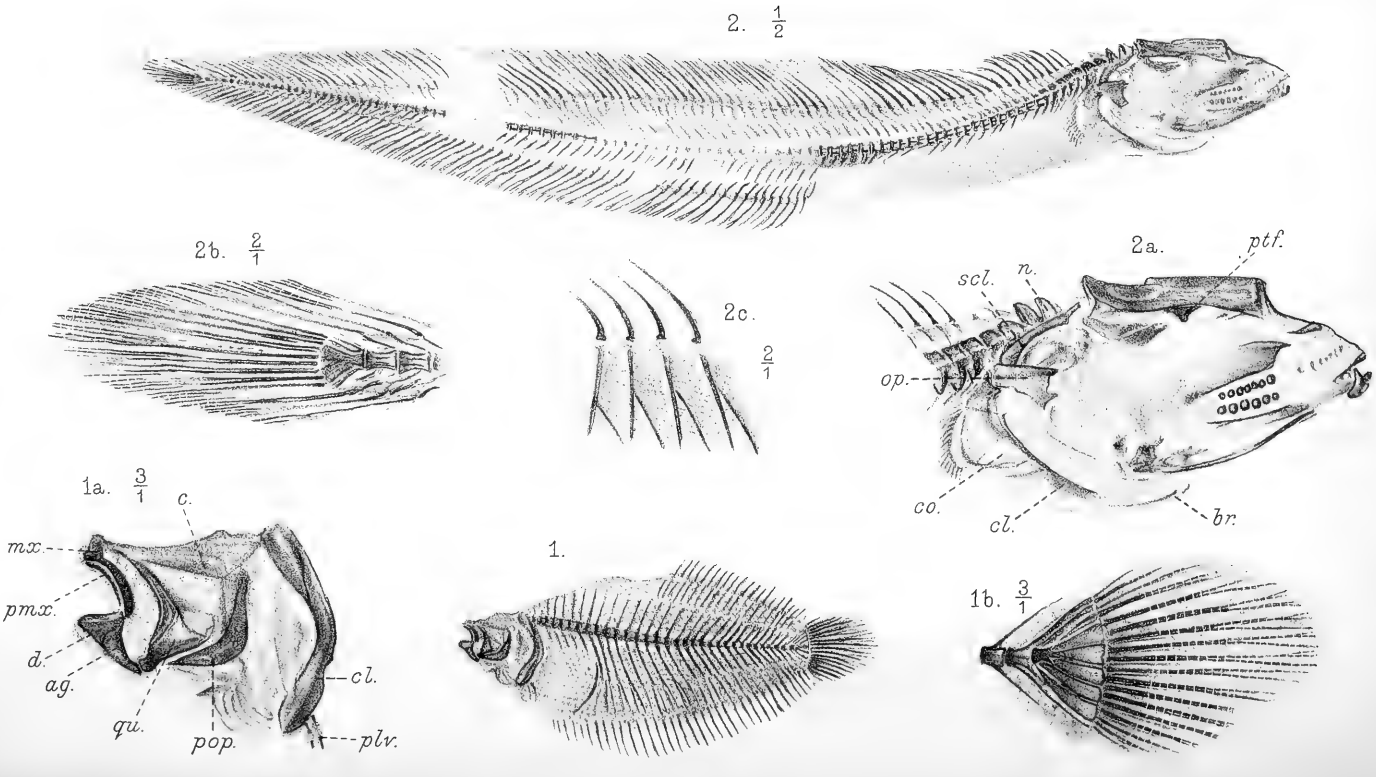
[1] D. S. Jordan & D. K. Goss, "A Review of the Flounders and Soles (Pleuronectidæ) of America and Europe": Ann. Rep. U.S. Fish. Comm. for 1886 (1889), p. 308.

jaws and the tail of the new fossil are proved to agree exactly with those of *Solea* itself, while the condition of the pelvic fins is uncertain, it may best be placed in this genus. It is distinguished from all the known species by its shape and by the number of its caudal vertebræ and anal fin-rays. It may therefore be named *S. eocenica* in allusion to the fact that it is the first example of its genus to be obtained from a formation so old as the Eocene.

2. Mylomyrus frangens, gen. et sp. nov. Pl. XXXIII, Figs. 2, 2*a*–*c*.

An eel measuring about 31 cm. in total length is well displayed from the right side, and lacks only the anterior part of the snout (Fig. 2). The length of the head with opercular apparatus equals about twice the maximum depth of the trunk, and is contained six times in the total length of the fish.

The crushed hinder half of the skull (Fig. 2*a*) shows that it is of the usual elongated, narrow, and depressed shape, with a prominent postfrontal bone (*ptf.*); and in the middle of both upper and lower jaws there is a single regular series of very large grinding teeth, which are enamelled, smooth, rather deep, and flattened at the apex. A more slender blunt tooth is seen near the symphysis of the mandible. The thin smooth operculum (*op.*) exhibits a horizontal strengthening ridge on its inner face. Traces of very slender branchiostegal rays (*br.*), not curving upwards round the operculum, are seen below. There are thirty-three vertebræ in the abdominal region, with constricted centra which are strengthened by a few slight longitudinal ridges. In about the twelve foremost vertebræ the neural spines (*n.*) are much expanded, the two first also comparatively deep, but further back they soon become slender rods like those of the caudal region. The broad triangular transverse processes are preserved both in some of the foremost and five of the hindmost abdominal vertebræ, and there are also some traces of short delicate ribs. There are about sixty-seven caudal vertebræ, with similar but more elongated centra, and very delicate neural and hæmal spines. The terminal vertebra bears a small fan-shaped expansion, suggestive of a hypural bone. In the pectoral arch the supraclavicle (*scl.*) is a relatively long and slender bone, nearly reaching the occiput; and the almost equally slender clavicle (*cl.*) bears in its upper half a delicate and much-expanded scapular arch, of which the coracoid (*co.*) forms the largest share. Of the pectoral fin only an obscure impression of the base is shown. The median fins are remarkably deep, continuous round the tail, with all the rays subdivided and distantly articulated in their distal half. The dorsal fin arises immediately above the scapular arch and comprises about ninety rays. The expansion at the end of the terminal caudal vertebra bears eight or nine comparatively crowded rays. The anal fin, which extends as far forward as the end of the abdominal region, consists of about sixty-five rays. The median fin must have been continuous round the end of the tail, but the space separating the terminal group of crowded rays from the last dorsal and anal rays respectively is greater than that between any two other fin-rays (Fig. 2*b*). There are no traces of scales in the lower part of



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

Eocene Fishes from Egypt.

the abdominal region, but above the vertebral column there are remains of calcifications along the lateral line; while both here and over the whole of the caudal region there is a curious mottling (Fig. 2*c*) suggestive of a fine and delicate squamation.

Though in all respects a typical eel, the fossil now described evidently represents one of the more generalized and primitive forms of the group. Its relatively large supraclavicle, its conspicuous hypural bones, as well developed as those of a very young *Anguilla*,[1] and its extensive squamation, are all characters of low degree. The relatively great depth of its dorsal and anal fins is also noteworthy. Among known primitive eels it is distinguished by its large and powerful crushing teeth, and it may therefore be referred to a new genus under the name of *Mylomyrus*. The species, defined by its general proportions and by its vertebral and fin formula already detailed, may be known as *M. frangens*.

EXPLANATION OF PLATE XXXIII.

FIG. 1. *Solea eocenica*, sp. nov.; fish nat. size, with head (1*a*) and caudal fin (1*b*) enlarged three times. Eocene: Tura, near Cairo.

FIG. 2. *Mylomyrus frangens*, gen. et sp. nov.; fish one-half nat. size, with (2*a*) head, etc., nat. size, (2*b*) caudal fin enlarged twice, and (2*c*) portion of trunk showing scales, enlarged twice. Ibid.

ag. articulo-angular; *br.* branchiostegal rays; *cl.* clavicle; *co.* coracoid; *c.* cranium; *d.* dentary; *mx.* maxilla; *n.* neural spine; *op.* operculum; *plv.* pelvic fin-supports; *pmx.* premaxilla; *pop.* preoperculum; *ptf.* postfrontal; *qu.* quadrate; *scl.* supraclavicle.

VII.—NOTE ON A SECTION IN PROBABLE BAGSHOT BEDS ON SHOOTERS HILL, KENT.

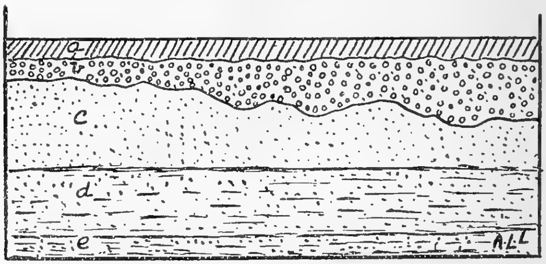
By A. L. LEACH.

IN 1905 trenches for electric mains were carried up the north-eastern slope of Shooters Hill, along Shrewsbury Lane to "The Bull", and thence down the western hill-slope along the Dover Road. From about 350 O.D. in Plum Lane to 424 O.D. at "The Bull" the trench ran for nearly two-thirds of a mile along the junction of the London Clay with the overlying group of sands, pebbles, and clayey gravels which form the 'gravel cap' of Shooters Hill. Neither the exact age of these superficial deposits nor their mode of formation—whether marine or fluviatile beds—is as yet known, but the general coarseness of the sands, the presence of pebbles of Lower Greensand chert, and the very stiff clayey matrix of the gravel distinguish them from typical Bagshot Beds, and moreover throughout the greater part of the section a sharp and irregular junction could be traced between them and the brown London Clay. At a few points, however, the top of the London Clay was seen to pass into pale-brown and yellowish sandy clays, sometimes of significant thickness. Thus in the Dover Road, about 100 yards above Christ Church, below the thick red clayey gravel of the 'cap', lay about 3 feet of yellow loam, the lower part of which became a pale-brown clay passing quite

[1] J. A. Ryder, "On the Origin of Heterocercy": Ann. Rep. U.S. Fish. Comm., 1884 (1886), p. 1051, pl. iv, fig. 4.

gradually into normal blue or brown London Clay with septarian nodules. In the same series of excavations (1905) a trench at the junction of Shrewsbury Lane with the Dover Road showed the Shooters Hill gravel resting irregularly on a bed of fine clean yellowish sand quite unlike anything previously noted in the numerous pits and trenches opened upon the Hill, but as unfortunately the trench was only a few feet deep the relation of this fine sand to the London Clay could not then be made out.

From the evidence of these sections I was led to think that patches of Bagshot Beds still remained beneath the 'gravel cap' on Shooters Hill, but until the present year no opportunity occurred of confirming this view. In July a sewer trench 12 feet deep was fortunately opened on the summit of the hill (424 O.D.) in the main road a few yards south-east of "The Bull", and the section displayed in this trench afforded what seems to me quite satisfactory proof of the existence of Bagshot Beds in fair thickness at this point.



Section of Bagshot Beds on Shooters Hill, Kent. *a*, road-metal; *b*, Shooters Hill gravel in reddish clay; *c*, very fine pale-buff sand; *d*, yellow and orange loamy sand; *e*, pale-brown loam and clay. Length of section, 20 feet. Vertical scale, $\frac{1}{10}$ inch to 1 foot.

The new section, which remained open only a few days, showed, beneath the road-metal, from 1 to 3 feet of red clayey gravel with a very irregular base, resting sharply upon a bed of very fine pale buff sand without a trace of pebbles. Under the centre of the road this sand was 5 feet thick; it passed downwards quite evenly into 3 feet of fine loamy sands, orange and yellow in colour, and quite without pebbles, and these in turn became more clayey and browner in colour and finally indistinguishable from ordinary brown London Clay. The total thickness of the loams and sands below the 'gravel cap' probably does not exceed 11 or 12 feet; the proofs of their Bagshot age depend on—

1. The quite gradual passage from and conformable junction with the London Clay.

2. The fineness of material and even bedding of the loams and sands, which differ in these respects very markedly from the very coarse, pebbly, and confusedly bedded sands of the 'gravel cap', and resemble the loams and sands of the probable Bagshots in Sheppey.

3. The very sharp and irregularly eroded junction between these fine sands and the 'gravel cap', which rests sometimes on the London

Clay, sometimes on the Bagshots. The Bagshot Beds, equally with the London Clay, lie below the irregular plane of erosion which forms the base of the 'gravel cap'.

In horizontal extent this thick patch of Bagshots may not cover more than a few square rods or acres at most. On the western slope of the hill it is certainly cut into deeply by the later gravel. In none of the writings of Trimmer, Goodchild, Prestwich, Spurrell, nor of Mr. Whitaker, who have all described the Shooters Hill sandy and clayey gravels from numerous old exposures, can I find any references to loams and sands like those described above, nor have I seen in many trenches and pits examined, during the last seven years, on the summit and slopes of the Hill any indications of other thick patches of similar beds. Although it therefore seems certain that the Bagshot Beds are confined to a small area on the very summit of the Hill, the interest of the patch is twofold. Firstly, it forms a link between the Bagshots of the main area and those at Hensbrook in Sheppey; and secondly, the height of the top of the London Clay can be definitely stated as 412 O.D. The basement pebble-bed of the London Clay was exposed in 1905 at about 240 O.D. at the junction of Well Hall Road and the Dover Road, half a mile from the section showing the top, described above. It has hitherto been impossible to estimate the true thickness of the London Clay of Shooters Hill, since it was not known that the top of the deposit remained beneath the 'gravel cap'. When the easterly dip through the Shooters Hill has been found an accurate estimation of the true thickness will be obtainable.

VIII.—On a Pygidium of *Bronteus* from the Devonian of Gerolstein, Eifel, preserved in the collection of the late Mr. Townshend M. Hall in the Athenæum, Barnstaple.

By Henry Woodward, LL.D., F.R.S., V.P.Z.S., F.G.S.

MANY years ago the late Mr. Townshend M. Hall, F.G.S., of Pilton, Barnstaple, specially devoted his energies to the geology and palæontology of the Devonian rocks of North Devon, and in addition to a set of fossils acquired from him, now in the British Museum (Natural History), he left a series of local fossils to the Museum in the Athenæum at Barnstaple. This collection has been kindly curated by Mr. J. G. Hamling, F.G.S., of The Close, Barnstaple, North Devon, who takes a deep interest in the geology of the district. Mr. Hamling has called my attention to an interesting specimen in this collection which proves to be a pygidium of *Bronteus*, collected by the late Mr. Townshend M. Hall in the Devonian rocks of Gerolstein in the Eifel, which country he had visited many years ago in company with the late Mr. John Edward Lee, F.G.S., of Torquay. In remembrance of that excursion Mr. Hall had presented the counterpart of this fossil to Mr. J. E. Lee, and it was supposed to be in this gentleman's collection, but it cannot now be found. There is, I believe, a good cast of the fossil in the Townshend Hall Collection in the Natural History Museum.

In his *Devonian Fauna of the South of England* the late Rev. G. F. Whidborne (Pal. Soc. Mon., pp. 32–42, pl. iii, 1892) describes and figures six English species of *Bronteus*, and remarks upon the difficulty of determining them by reason of the fact "that with the one exception of *B. flabellifer*, Goldfuss (in Mr. Vicary's collection), none of the heads and tails have occurred in contact". Besides this, the specimens are generally very imperfect, and "except in the case of the Bohemian species many of the foreign ones have been described from the pygidia alone" (op. cit., pp. 32, 33).

Although the pygidia of many species of Trilobites can hardly be relied upon for purposes of determination, those of the genus *Bronteus*, as pointed out by Barrande, are often extremely well marked and characteristic. This happens to be the case with regard to Mr. T. M. Hall's specimen of a detached pygidium from Gerolstein, and I am encouraged, therefore, to offer a figure and description of it here.

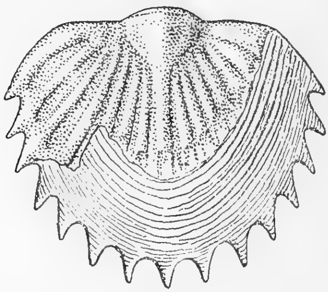


Fig. 1. *Bronteus Halli*, sp. nov. (pygidium). Lower Middle Devonian: Gerolstein, Eifel. The original specimen is preserved in the Townshend Hall Collection in the Athenæum, Barnstaple. Enlarged twice nat. size.

Description of Mr. Townshend Hall's specimen. (Fig. 1.) In outline the broadly expanded tail-shield or pygidium is nearly circular, though somewhat truncated for 20 mm. along its anterior border, where it articulated with the thorax, its extreme breadth being 30 mm. and its length 28 mm., presenting with its coalesced radiating ribs the appearance of an elegant fan. The surface is but slightly convex, with the exception of the small triangular, much elevated, central area on its anterior flattened border, which is, in fact, the distal extremity of the median axis of the trilobite, being also the point of articulation between the pygidium and the last free and movable segment of the thorax. From this triangular raised axis, which is 8 mm. in breadth and 5 mm. in length, radiate fourteen rounded ribs, seven on either side of the median raised ridge, this latter being much wider and not bifurcated; it is, indeed, a prolongation of the distal end of the triangular axis. The first rib, which forms the latero-anterior margin of the pygidium, is strongly curved downwards and is broader near its centre than the six which follow; the others are about of equal thickness; they are all more slender at first, but become gradually stouter as they approach the margin, where they terminate in short flattened strong marginal spines. The interspaces between the ribs form smooth sulci, narrow at the anterior end, where they diverge from the axis, and broader near the flattened margin, where they gradually die out.

The shelly cuticle or crust of the pygidium has been lost along about three-fourths of its expanded margin, exposing the cast of the under surface of the caudal shield, which was covered by a series of fine, wavy, more or less parallel lines, as may also be seen upon the decorticated surface of the pygidium in *Illænus*, *Ogygia*, *Asaphus*, and some other genera.

In the genus *Bronteus* the coalesced segments forming the pygidium are usually seven in number, but two species are recorded by Barrande with only six, viz. *B. laticauda*, Wahl., and *B. hibernica*, Portl., while one species, *B. radiatus*, Munst., is said to have eight ribs in the tail-shield. The prolongation of the axis forming the median ridge to the pygidium is most commonly bifurcated [1] at or near the distal end. With very few exceptions the margin of the pygidium in the several species of *Bronteus* is smooth and destitute of spines or spinous prolongations along its border.

Mr. Townshend Hall's specimen (Fig. 1) has fifteen spines around the tail-shield, marking the terminations of the pleuræ of the seven coalesced segments which compose it, the fifteenth median spine being a prolongation of the distal end of the axis.

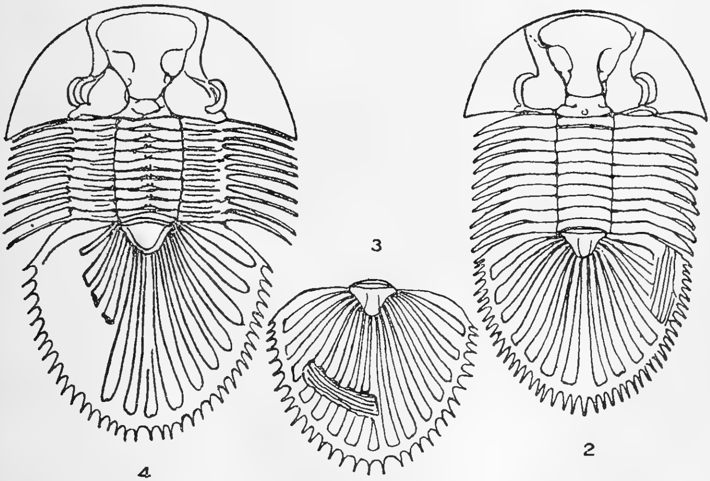


Fig. 2. *Bronteus thysanopeltis*, Barr. Upper Silurian: Bohemia. The median ridge of the tail does not appear to be bifurcated; it has forty-five marginal spines on the pygidium.

,, 3. Id. A detached pygidium, having thirty-three spines along its border. This figure has the median ridge of the tail-shield bifurcated.

,, 4. *B. speciosus*, Corda. Lower Middle Devonian. With forty marginal spines to its pygidium. This species has the median ridge bifurcated.

[1] Thirty-one species being bifurcate, and nineteen non-bifurcate.

One Upper Silurian species (Fig. 2), *B. thysanopeltis*, Barr.,[1] has as many as forty-five marginal spines on its caudal shield, while another detached pygidium shows thirty-three spines upon its border[2] (Fig. 3). *B.* (*Thysanopeltis*) *speciosus*, Corda, from the Lower Middle Devonian, has forty marginal spines around its caudal shield[3] (Fig. 4), while another Devonian form referred to by Barrande[4] has about twenty-two spines.[5]

We may, I think, safely conclude that Mr. Townshend Hall's Gerolstein specimen is quite distinct from any other Devonian form. It may be characterized as having seven coalesced segments in its caudal shield, indicated by seven marginal spines, marking the lateral termination of the pleuræ, and by a single *non*-bifurcate stout median lobe, being a prolongation of the axis of the caudal shield, and terminated by a similar median spine upon its margin. The decorticated portion of the margin of the shield shows that the underside was etched by numerous fine parallel wavy lines, extending over even the lower surface of the marginal spines.

I propose to designate this Gerolstein form as *B. Halli*, after my late friend Townshend M. Hall, who did so much good work in the Devonian rocks of North Devon.

IX.—The Characteristics of British Earthquakes: A Summary of Twenty-one Years' Work.

By Charles Davison, Sc.D., F.G.S.

For a detailed study of the earthquakes of any district, an interval of twenty-one years is too brief. Long-period variations of frequency cannot be established. We can form no satisfactory conception of the distribution of seismic energy in space, for some foci may lie inactive for a much longer time, while others may continue in operation without apparent change. But, to ascertain the characteristic features of the earthquakes, to investigate their relations with those which precede and follow them, or to trace their connexion with the structure of the central districts, such an interval is possibly of sufficient length. In any case, the defects resulting from its brevity may be partly compensated by uniformity in treatment and in the methods of investigation.

[1] J. Barrande, *Système Silurien du Centre de la Bohême*, pt. i, vol. i, 1852, Texte Crustacés: Trilobites, p. 843, pl. xlvii, fig. 6.

[2] Op. cit., pl. xlvii, figs. 11, 12.

[3] Kayser's *Text-book of Comparative Geology* (translated and edited by Philip Lake), p. 121, fig. 5, 1893; and Gürich, *Leitfossilien*, Taf. xlvii, fig. 1.

[4] See explanation to pl. xlvii, under fig. 12.

[5] Barrande writes—"*Bronteus acanthopeltis* (Schnur) was recently discovered in the Eifel by Professor Schnur, of Trèves. It presents the nearest analogy with *B. thysanopeltis*. It is distinguished, however, by possessing less than half the number of spines around the pygidium. It only came to our knowledge by the kindness of Professor Schnur, who was so good as to send it to us at the moment when our text was going to press." [I cannot, I regret to say, find any figure of this species.]

The earthquakes of the last twenty-one years have been in no respect unusual. None has exhibited in its central area so destructive an intensity as the Colchester earthquake of 1884. Nor has any borne a train of after-shocks so numerous as that of the Comrie earthquake of 1839. Three earthquakes (those of Hereford in 1896, Inverness in 1901, and Swansea in 1906) were, however, strong enough to cause considerable damage to buildings; and, in the low-lying country on the south side of the Ochil Hills, there have been many slight shocks which in their nature and frequency approximate towards those which have made the name of Comrie famous.

Several of the more important seismic centres in this country have lain dormant or nearly so during these years. Rumbling noises, apparently underground, are said to have been heard in West Mersea Island, off the coast of Essex, and, if seismic, may possibly be connected with the centre which gave rise to the Colchester earthquake twenty-six years ago. The Comrie focus is represented by three slight shocks, and seems to have relapsed into that state of quiescence which may precede another outburst of energy. On the other hand, the important focus in the neighbourhood of Inverness has been unusually active, and other well-known foci have exhibited those signs of flickering vitality which from time to time interrupt the monotony of our geological existence.

Hardly any part of Great Britain has been entirely free from the transitory effects of earthquake shocks, the only districts left undisturbed being the greater part of Durham and Northumberland and some of the southern counties of Scotland.

Frequency.

Taking into account only those earthquakes recorded by more than one observer, the total number which have occurred in Great Britain during the interval considered is 250, the greatest numbers in any single year being 25 in 1890, 23 in 1901 and 1906, and 20 in 1892, and the least numbers being 1 in 1897 and 1899, and 2 in 1895 and 1902. Of the total number, 50 (including two with submarine origins off the coasts of Cornwall) originated in England, 27 in Wales, and 173 in Scotland. Thus, on an average, one earthquake occurs in Great Britain every month. Also, out of every 20 earthquakes, 4 occur in England, 2 in Wales, and 14 in Scotland; or, taking area into account, 2 occur in England, 7 in Wales, and 11 in Scotland.

Intensity and Disturbed Area.

Of the 250 earthquakes, 3 were of intensity 8 of the Rossi-Forel scale, 9 of intensity 7, 7 of intensity 6, 29 of intensity 5, 64 of intensity 4, 127 of intensity 3 or about 3, while 11 were merely earth-sounds unaccompanied by any perceptible tremor. In Japan, 220 of the shocks would be described as weak, 16 as strong, and 3 as violent; in Italy, 127 would be considered slight, 64 moderate, 36 strong, and 12 very strong.

The connexion between the intensity of the shocks and the areas disturbed by them is shown in the following table:—

TABLE I.

Intensity.	Disturbed Area in Square Miles.		
	Maximum.	Minimum.	Average.
8	98000	33000	65900
7	63600	1000	24500
6	3100	74	1200
5	3000	90	850
4	1130	28	260
3	219	18½	126

The intensity at the epicentre is not, however, proportional to the energy expended in producing an earthquake, for it depends to a great extent on the depth of the focus and the nature of the surface rocks. A more satisfactory though still a rough test is the area included within a given isoseismal, say that of intensity 4.[1] If an earthquake be regarded as *strong* when this area exceeds 5000 square miles, as *moderate* when it lies between 1000 and 5000 square miles, and as *slight* when it is less than 1000 square miles, then Great Britain has been visited during the last twenty-one years by 9 strong, 7 moderate, and 223 slight earthquakes, and 11 earth-sounds.[2]

PERIODICITY.

The monthly distribution of earthquakes is given in the next Table (II), the upper figure denoting the number of earthquakes during the first 14 days in February and the first 15 days in each of the other months, the lower figure the number observed during the remainder of each month.

TABLE II.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
7	2	7	10	8	2	17	3	2	9	8	6
17	6	7	4	9	17	6	17	28	19	11	28

Applying the method of overlapping means[3] to determine the annual and semi-annual periods, it appears that there is a well-marked annual period with its maximum in October, the amplitude being

[1] The disturbed area is an unsatisfactory test, for the Pembroke earthquake of 1893 was felt over a larger area than the stronger shock of 1892, and the Derby earthquake of 1904 than the stronger earthquake of 1903.

[2] The strong earthquakes are those of Pembroke in 1892 and 1893, Hereford in 1896, Inverness in 1901, Derby in 1903 and 1904, Carnarvon in 1903, Doncaster in 1905, and Swansea in 1906. The moderate earthquakes are those of Bolton in 1889, Inverness in 1890, Leicester in 1893, Carlisle in 1901, Strontian in 1902, Derby in 1906, and Oban in 1907.

[3] Phil. Trans., 1893 A, pp. 1108–15; Boll. della Soc. Sismol. Ital., vol. iv, 1898, pp. 89–100.

·37 of the average monthly number. The semi-annual period is less pronounced, and its reality is doubtful owing to the smallness of the amplitude, which is only ·14. The analysis gives the maximum epochs in the middle of May and November.

The next Table (III) illustrates the hourly distribution of the earthquakes, those which are reported as occurring at the exact hours being divided equally between the hours before and after.

TABLE III.

	0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12
a.m. .	9	17	6·5	10	16	9	9·5	10	8·5	9·5	10	6
p.m. .	4	10	5	7	16	9	9	6	5	11	12	9

As the shocks were not recorded instrumentally, it is useless applying the method of overlapping means to these figures. The variations in frequency are no doubt chiefly due to more favourable conditions existing at certain times of the day, as, for example, the early hours of the night (9 to 11) and the hour 1 to 2 a.m., when many persons lie awake after their first sleep. The increase of apparent frequency in these hours is manifest in every earthquake catalogue, but a feature which seems to be peculiar to British earthquakes is the large number felt from 4 to 5 p.m. Of the sixteen earthquakes recorded during this hour, seven occurred on Sunday, while two others were strong shocks that could not have passed unnoticed at any time of the day. It is, therefore, probable that the number of slight shocks recorded in Great Britain would be almost doubled if all the hours of the day were as restful as those devoted to the modern institutions of the Sunday afternoon siesta and the 5 o'clock tea.

NATURE OF THE SHOCK.

As a general rule, in British earthquakes the shock consists of a single series of vibrations, which increase rapidly in strength, until one or several of greater prominence are felt, after which they fade as rapidly away. The average duration of the shock in such cases is about four seconds, though, as in the Carnarvon earthquake of 1903, it may be as much as 6·7 seconds. In very slight earthquakes there are no prominent vibrations, and only a weak tremor is perceived; in slight earthquakes the shock often begins with a single prominent vibration, like the thud of a falling body, followed by a brief tremor as such a fall would produce in a building. In these earthquakes the average duration of the shock seldom exceeds two seconds and is often less.

In a few earthquakes the shock consists of two parts, in each of which the vibrations increase to a maximum and then die away. The two series generally differ in intensity and duration, and occasionally in the period of their vibrations. As a rule, the interval between the two parts is one of absolute rest and quiet, but occasionally it is occupied by a weak tremor and sound which are observed only near the epicentre, so that, at a distance from that region, the shock consists of two entirely detached parts. The average duration of the interval of rest is 2·7 seconds, and that of the whole shock about six or eight seconds, rising, as in the Hereford earthquake of 1896, to 9·3 seconds. It is now known[1] that, in these cases, the double shock is caused by impulses in two distinct foci, the impulses being either simultaneous or separated by an interval which is often less than the time taken by the earth-waves to travel from one focus to the other. Of the 250 earthquakes, at least eleven (or about 4 per cent.) belong to this class of twin earthquakes.

Sound-Phenomena.

The sound which accompanies an earthquake is a deep rumbling sound, so low that it is inaudible to some persons, while to others in the same place it appears louder than any thunder. That the inaudibility is not due to inattention is clear from the fact that, in the Inverness earthquake of 1901 (which occurred at 1.24 a.m.), 86 per cent. of the observers who were awake, and 84 per cent. of those who were asleep, heard the sound which preceded the shock. For the Doncaster earthquake of 1905 (which occurred at 1.37 a.m.) the corresponding figures are 93 and 91 per cent.

Of the 250 earthquakes, 197 (or 79 per cent.) were certainly accompanied by sound. In 4 cases, the observers state that they heard no sound; in 49 cases, no reference is made to the sound-phenomena. Of these 53 earthquakes, 28 occurred in the Ochil district, 10 in Glen Garry, 11 were after-shocks of strong earthquakes, and 4 were slight earthquakes in various places. But all, without exception, were feeble tremors, the number of observers was small, and there can be little doubt that, with a larger number, there would have been some who would have heard and recorded the sound. It is probable, therefore, that all British earthquakes are attended by audible vibrations.

In strong earthquakes the sound was heard on an average by 83 per cent. of the observers, in moderate earthquakes by 93 per cent., and in slight earthquakes by 97 per cent. This difference is partly due to the fact that, in slight earthquakes, the sound is generally a much more prominent feature than the shock, and partly to the variable size of the sound-area. In slight earthquakes, the sound-area either coincides with or overlaps the disturbed area; in moderate earthquakes, the two areas are approximately coincident; in strong earthquakes, the sound-area falls short of the boundary of the disturbed area, the sound-area varying from 43 per cent. of the disturbed area in the Derby earthquake of 1904 to 82 per cent. in the Inverness earthquake of 1901. On an average, the sound-area is 64 per cent., or roughly two-thirds, of the disturbed area.

In moderate and slight earthquakes, the percentage of audibility is practically uniform throughout the area affected. In strong earthquakes, with a large disturbed area, the decline in audibility as the

[1] Quart. Journ. Geol. Soc., vol. lxi, 1905, pp. 18–33.

sound-waves recede from the centre is distinctly marked. Within the central isoseismal, 97 per cent. of the observers on an average hear the sound, and in the successive zones bounded by the isoseismals, the average percentages of audibility are 94, 88, 69, and 60 respectively. Close to the boundary of the sound-area, there is a rapid decline to zero.

The sound may be classified under one of the following types: (1) Wagons, trains, traction-engines, etc., passing, (2) thunder, (3) wind or a chimney on fire, (4) loads of stones falling, (5) the fall of a heavy body, (6) explosions, and (7) miscellaneous sounds, such as the trampling of many animals, the roar of a waterfall, etc. The following Table (IV) shows the average frequency of reference (in percentages of the total number) to these different types for the three classes of British earthquakes. In the last two lines of the table are given separate figures for two divisions of slight earthquakes, the first division having a long focus and the second division a short focus.

Table IV.

Earthquakes.	Type.						
	1	2	3	4	5	6	7
Strong	46	24	10	5	3	7	5
Moderate	49	26	4	5	5	8	3
Slight	33	29	5	7	9	14	3
,, (long focus) . .	40	37	4	1	4	10	4
,, (short focus) . .	29	26	6	9	11	16	3

Omitting the seventh type, the first three may be regarded as of long and the next three as of short duration. The percentage of reference to types of short duration is 16 for strong earthquakes, 19 for moderate earthquakes, 31 for slight earthquakes, or 16 for slight earthquakes with a long focus and 37 for those with a short focus. It will be noticed that the sounds attending strong and moderate earthquakes, and also slight earthquakes with a long focus, are approximately of the same character.

In the neighbourhood of the epicentre, the sound varies greatly in character and intensity. When the shock begins, the sound becomes deeper and more rumbling, and with the strongest vibrations deep booming explosive crashes are heard by those observers who possess a low limit of audibility. In the zone outside the central isoseismal the crashes are less frequently heard, but still the sound changes perceptibly while the shock is felt, becoming rough and grating; while, near the boundary of the sound-area, it is a low monotonous moan like the boom of very distant thunder. Table V shows the variation in type in strong earthquakes, beginning with the central zone A, and continuing with the zones B, C, D, E, bounded by successive pairs of isoseismals.

TABLE V.

Zone.	Type.						
	1	2	3	4	5	6	7
A	36	30	6	8	3	12	4
B	44	28	9	6	5	7	5
C	50	22	11	4	5	5	4
D	47	21	15	3	4	4	5
E	47	21	25	1	1	1	1

Thus, as the distance from the origin increases, there is a steady diminution in the references to types 2, 4, and 6, an increase in those to type 3, and on the whole an increase in those to type 1.[1] Omitting type 7, the percentage of references to the types of long duration (1 to 3) for successive zones are 76, 81, 86, 88, and 94, implying, not that the duration of the sound increases, but that the sound becomes smoother and more monotonous in the outer zones.

Occasionally, the sound is heard before the shock and becomes inaudible as soon as the first vibrations are felt. With a very few exceptions, however, the sound, when heard at all, accompanies the shock, though it is heard by many observers both before and after the shock. The time-relations of the principal epochs of the sound and shock are given in Table VI, in which the figures in the columns headed *p*, *c*, and *f* denote the number of records per cent. in which each epoch of the sound preceded, coincided with, or followed the corresponding epoch of the shock; those in the columns headed *g*, *e*, and *l* denote the number of records per cent. in which the duration of the sound was greater than, equal to, or less than that of the shock.

TABLE VI.

Earthquakes.	Beginning.			End.			Epoch of Max. Int.			Relative Duration.		
	p	*c*	*f*	*p*	*c*	*f*	*p*	*c*	*f*	*g*	*e*	*l*
Strong . .	66	25	9	15	40	45	22	68	10	68	27	5
Moderate . .	66	29	5	12	43	45	24	73	3	75	23	2
Slight . . .	59	34	7	14	47	40	33	67	...	58	41	1

This table shows that there is a close resemblance, as regards time-relations, between all three classes of earthquakes. Roughly speaking, two out of every three observers who hear the sound at all hear the fore-sound, two out of every five hear the after-sound, while to two out of every three the sound is loudest at the instant when the shock is strongest.

[1] The slight decrease in the two outer zones is probably due to the comparative uniformity in the intensity of the sound at great distances.

The next Table (VII) shows how slightly the time-relations of the sound and shock vary throughout the sound-areas of strong earthquakes.

TABLE VII.

Zone.	Beginning.			End.			Relative Duration.		
	p	*c*	*f*	*p*	*c*	*f*	*g*	*e*	*l*
A	67	30	3	19	42	38	70	28	2
B	69	24	7	15	42	44	69	24	7
C	70	20	10	15	44	41	66	27	7
D	63	25	12	21	44	36	54	38	8

The precedence of the shock by the sound is generally attributed to a greater velocity of the sound. If this were the case, however, the sound, with increasing distance, would be more generally heard before the shock and less frequently after it. There is no evidence whatever of such a displacement of the sound in the above Table. The only tendency distinctly noticeable is towards equality in the relative duration, and this might be expected from the gradual quenching of the weaker vibrations which constitute the fore-sound and after-sound.

MINOR SHOCKS.

The series of slight shocks which occur in Great Britain belong to two classes, one including those which have been confined to Glen Garry and the Ochil district, the other those which precede and follow the stronger earthquakes.

The Glen Garry series lasted for about ten years, from 1889 to 1899. In this interval 41 slight shocks were recorded, the majority occurring during the three years 1890–2, when the numbers felt were 11, 18, and 6 respectively. The Ochil series began in the year 1900, and is still (1910) continuing with unabated frequency. Up to the end of 1909, the total number recorded is 83, 4 having occurred in 1900, 1 in 1903, 10 in 1905, 19 in 1906, 13 in 1907, 17 in 1908, and 18 in 1909. They vary considerably in intensity. Two, namely, those of September 21, 1905, and October 20, 1908, were strong within the epicentral district, and each disturbed an area of about a thousand square miles. But they should be regarded as stronger shocks than usual, rather than as the parents of trains of after-shocks, for the slight shocks which followed were not more frequent immediately after them than at other times.

True accessory shocks are almost confined to the strong earthquakes which disturb areas of more than 5000 square miles. The total number of such shocks is 71, all but five of which attended the strong earthquakes and the Inverness earthquake of 1890, and of the majority 15 were fore-shocks and 51 after-shocks. It is worthy of notice that, as regards after-shocks, there is a marked difference between simple and twin earthquakes. The three simple earthquakes of Inverness in

1890 and 1901 and Carnarvon in 1903 were followed by 33 after-shocks, and the seven strong twin earthquakes by 18 after-shocks.

Distribution in Space.

The total number of earthquakes which it is possible to associate with known lines of fault or folding is 199.[1] Of the 199 earthquakes, 153 were probably connected with faults of the Caledonian system, 23 with Charnian, 10 with Malvernian, and 13 with Armorican faults. In Scotland, with the exception of the Loch Broom earthquake of 1892, which was connected with a Charnian fault, the remaining 129 shocks were due to movements along Caledonian faults. In England 15 earthquakes were connected with Caledonian faults, 22 with Charnian, 6 with Malvernian, and 5 with Armorican faults. In north-west and central Wales, the earthquakes were connected with Caledonian faults, in the south of Wales with Armorican faults. Of the nine strong earthquakes, the Inverness earthquake of 1901, the Derby earthquakes of 1903 and 1904, the Carnarvon earthquake of 1903, and the Doncaster earthquake of 1905 were connected with Caledonian faults, the Hereford earthquake of 1896 with a Charnian fault, and the Pembroke earthquakes of 1892 and 1893 and the Swansea earthquake of 1906 with Armorican faults. The last four earthquakes were the strongest felt in this country throughout the twenty-one years. Twin earthquakes are entirely confined to England and the south of Wales.

Origin of British Earthquakes.

The study of British earthquakes has led to the association of a large number of them with known faults, especially in those in which there is reason to think that the foci were situated at a small depth. In other cases, the investigation of the earthquakes has thrown light on the structure of the epicentral districts at depths far beyond the reach of methods at the disposal of the field-geologist. For instance, the complicated structure of the English Lake District is superposed on one of a more simple character, the Carlisle earthquakes of 1901 having originated in a fault not less than 23 miles in length, and directed approximately N. 5° E. Similarly, in south Glamorgan, as shown by the Swansea earthquake of 1906, a fault at least 22½ miles long runs in a direction about E. 5° N. from west of Swansea to the neighbourhood of Llwynpia.

A rough approximation to the length of the seismic focus is given by the difference in length between the longer and shorter axes of the innermost isoseismal.[2] In estimating the average length of the focus for the different classes of British earthquakes, after-shocks are omitted, as in them the length of the focus is governed to some extent by that of the principal earthquake. The results are as follows:—

[1] The earthquakes omitted are the 41 shocks felt in Glen Garry from 1889 to 1899, 2 shocks near Tadcaster in 1890, 5 in Pembrokeshire in 1893, 3 in Annandale in 1894 and 1896, and 1 near Beddgelert in 1904.

[2] Gerland's *Beitrage zur Geophysik*, vol. ix, 1908, p. 224.

TABLE VIII.

Earthquakes.	Mean length of focus in miles.
Strong . .	$12\frac{1}{4}$
Moderate . .	13
Slight, *a* . .	12
,, *b* . .	$4\frac{1}{4}$

Slight earthquakes are obviously divisible into two sub-classes, the first in which the focus is 9 miles or more in length, the second in which the focus is 6 miles or less in length.[1] The above Table gives the reason why the sound should be of nearly the same character in strong, moderate, and the first division of slight earthquakes. Thus, the intensity of all but the slightest earthquakes depends, not on the magnitude of the focus, so much as on the amount of relative displacement along the surface of the fault.

British earthquakes, according to the nature of the shock, are divisible into two classes, simple and twin, and this classification corresponds to a difference in origin. Simple earthquakes are due to continuous slips, as a rule along strike faults; twin earthquakes are caused by rotation of the median limb of a crust-fold along a transverse fault, the two foci coinciding with the crest and trough of the fold, the interfocal region with the practically undisplaced portion of the median limb about which the rotation takes place. In this connexion, it is worthy of notice that the average distance between the epicentres of British twin earthquakes is 10 or 11 miles, which agrees closely with the average distance of 9 to 12 miles between the crests of the great crust-folds in France.

The average length of the focus in twin earthquakes is about 12 miles. Thus, the average length of focus in twin earthquakes and in other earthquakes, whether strong or moderate or, in certain cases, slight, is nearly the same, and is probably equal to, or it may be slightly more than, the average distance between the crests of the crust-folds. In other words, the magnitude of the crust-folds seems to determine the length of fault-slips along strike faults as well as along transverse faults.

NOTICES OF MEMOIRS.

I.—THE SIGNIFICANCE OF EARLY AND OF PLEISTOCENE GLACIATIONS.[2]

By MARSDEN MANSON, Ph.D.

THE objects of this paper are to point out the significant differences between the preceding, accompanying, and succeeding phenomena of early glaciations and the corresponding phenomena of Pleistocene

[1] In determining the average for the second sub-class, a large number of very slight shocks were unavoidably omitted; their inclusion would, of course, lower the average considerably.

[2] Being an abstract of a paper read before the Eleventh Session of the Int. Geol. Congress, Stockholm, August, 1910.

and present glaciation. One of the broadest and most recent summaries on the subject is that of Professor T. W. Edgeworth David, F.R.S.[1] He finds that in the following horizons the presence of evidences of extensive ice-action is quite firmly established:—Lower Cambrian, Devonian, Permo-Carboniferous, Pleistocene.

Professor A. P. Coleman also reviews the whole subject very clearly, and finds four periods of extensive glaciations—(1) Lower Huronian, left its effects over hundreds of thousands of square miles;[2] (2) Early Cambrian, in widely separated regions; (3) Permo-Carboniferous, for large parts of the world; (4) Pleistocene, very general. We therefore accept, for the purposes of this discussion, that ice-action of great extent occurred in these periods.

Cambrian Glacial Action.—Evidences of the action of ice in Cambrian time have been observed from Arctic, through north temperate and tropical, and in south tropical latitudes. Evidences of Cambrian life have been found which are of wide distribution as to latitudes and indicative of warm seas. "The testimony of the fossils, wherever gathered, implies nearly uniform climatic conditions, not only over our own continent, but throughout all the earth where records of the Cambrian Period are found."[3] The extremely wide range of life in Cambrian time justified Dana in saying, "There was no frigid zone, and there may have been no excessively torrid zone."[4]

Evidences of Glacial Action in the Devonian Era.—When the evidences of glacial action in the Devonian era are compared it is found that they embrace nearly as wide a distribution in latitude as do the evidences of the life of that era, and that, like the distribution of temperature and of life in the preceding Silurian and succeeding Carboniferous era, both life and glacial action were distinctly non-zonal in distribution, and the former indicated warm temperate or tropical conditions.

Permo-Carboniferous Ice-sheets.—During Permo-Carboniferous time extensive sheets of ice were laid down in the tropical latitudes of both hemispheres. During this period the life was indicative of temperate conditions rather than Arctic, and its distribution was worldwide. "The Permian Period lies in the midst of geological history, with periods of great uniformity and remarkable Polar geniality both before and after it."[5]

It must be recognized at once that zones of temperature did not prevail immediately before, during, nor immediately after the Permo-Carboniferous glaciation; that whatever part solar radiation played in the climatic distribution of that age it was not the controlling part, as at present, and that to attempt to fit such a distribution of temperature to solar radiation involves suppositions and hypotheses which have not been made to harmonize with present conceptions of solar-controlled climates. The volcanic heat liberated at the close of this era, and that

[1] See Trans. Tenth Int. Geol. Cong., Mexico, vol. i, pp. 437–82, 1906.

[2] Bull. Geol. Soc. Am., vol. xix, pp. 347–69, November, 1908. See also Davis, ibid., vol. xvii, p. 414, August, 1906.

[3] Chamberlin & Salisbury, *Geology*, ii, p. 273.

[4] Manual, 4th ed., p. 484.

[5] Chamberlin & Salisbury, ii, p. 656.

slowly brought into effect from cooling lava and radio-active substances by subsequent denudation, would tend to raise the temperature of the air, from which it could escape only by slow processes[1] under the powerful conservative influences of solar radiation. The widespread geniality of the succeeding period may be, in part at least, attributed to this accession of heat—the geniality compared with that of the preceding period, when tropical life flourished at all latitudes. Taking the three epochs in succession, Carboniferous, Permian, and Triassic, it appears that the Permian was a period of marked temperature depression in a series of non-zonal climates.[2]

Pleistocene Glaciation and Conditions.—Pleistocene glaciation followed a period during which cold temperate forms of life were for the first time distinctly developed over wide ranges of latitude, which, during the immediately preceding period, were occupied by temperate forms. For the first time also marine life of Arctic habit took possession of oceans previously supporting more temperate forms only. The cold became so general as to be 'worldwide' in its effects.

A Review and Comparison of these Glaciations and of Life.—When the distribution in latitude of the evidences of early glaciations and of life are compared with Pleistocene glaciations and the distributions of modern life, it is observed—

1. That both early and late glaciations and all life prior to the modern era were distributed over extreme ranges of latitude and apparently without regard to exposure to solar radiation.

Pleistocene glaciation may have reached its maxima progressively at different latitudes, that is, whatever may have been the maximum extension of glaciation in the latitude of the tropics, this maximum was apparently reached prior to the maximum in, say, latitudes 45 to 55 degrees; similarly, glacial maxima in these latitudes may have preceded maximum glaciations in Polar latitudes. But taken as a whole, Pleistocene glaciations were not laid down in accordance with present zonally distributed climates.

2. That early glaciations were preceded, accompanied, and followed by a widespread distribution of tropical and temperate forms of life and by warm oceans, while Pleistocene glaciation was 'phenomenal', was preceded by a period of widespread cold temperate life, and accompanied by colder oceans than had previously prevailed.

3. That the earlier glaciations were followed by periods of widespread tropical or temperate life, while Pleistocene glaciation was followed by a period in which life and temperatures were restricted to zones distinctly dependent upon solar radiation for their establishment and maintenance.

A deduction which seems fully justified is that up to the culmination of Pleistocene glaciation zones of temperature were scarcely perceptible, if at all, which deduction is confirmed by both the wide distributions of life and the evidences of glacial action in low latitudes in the pre-Pleistocene eras.

The absence of distinct zones of climate is highly significant, and

[1] Chamberlin & Salisbury, ii, p. 672.

[2] Neumayr held that there were climatic zones in Jurassic and Cretaceous times; see W. T. Blanford, Address to Geol. Soc., 1890, p. 55.—Ed. Geol. Mag.

clearly established the fact that a solar control of climates similar to that at present existing did not prevail prior to the modern era,[1] or that some factor was active which did not admit of the zonally distributed climates of solar control.

The distribution of ice and of fossil life during Huronian, Cambrian, and Permo-Carboniferous time, and during preceding and succeeding eras to the close of Pleistocene time, are so widely at variance with a solar-controlled distribution of temperatures like the present that it seems impossible to assign these phenomena merely to variations in solar radiation. Under solar control, for instance, what would become of Polar and mid-latitude life while tropical latitudes were glaciated nearly or quite to sea-level?

The phenomena of geological and present climates may be interpreted under the hypothesis that prior to the Recent or Human Epoch the earth was more continuously clouded, and thereby deprived of the zonal temperature control of solar radiation.[2]

When these evidences of ice-action and the phenomena of life are broadly compared, under this hypothesis, it appears to the writer—(1) That accordingly ice-fields were laid down generally without regard to latitude, although Pleistocene glaciation reached its maximum along the broadest land areas under the north temperate rain-belt, and this maximum may have been reached after the inauguration of solar control in tropical latitudes. (2) That the earlier glaciations were contemporaneous with tropical and temperate land and marine forms, and that the greater exposure of the continents to loss of heat, and their low specific heat and conductivity, caused them to cool more readily, thus frequently forcing land animals to seek warmer conditions in the oceans, and from these permanently marine forms of life have descended. (3) That Pleistocene glaciation followed an extremely gradual although fluctuating refrigeration of the earth as a whole when its crustal condition became more stable than ever before and its oceans for the first time fully and completely chilled, and that the stress of cold was so general that the oceans did not then offer more congenial conditions to even the cold temperate land life of the immediately preceding period; that this stress was first relieved in regions of least cloudiness by the penetration of solar radiation to the surface, and that more moderate conditions spread thence into the solar-controlled, zonally distributed temperatures of to-day; that the accession of heat through continuous exposure and the trapping of solar radiation, converted into long wave-length rays, is a cumulative process which has recorded and is yet recording its gradual but irregular progressiveness by the removal of Pleistocene glacial conditions and the corresponding advance of life. (4) That only after the culmination of this marked and phenomenal glaciation did temperatures and life pass from a non-zonal to a zonal distribution, which manifests itself in zones of life and of climates, and marks

[1] There is an apparently zonal distribution of the very much mixed groups of Pliocene life which may have resulted from a similar distribution of temperatures, but exceptional conditions warn us against too implicit an acceptance of this conclusion.

[2] See Trans. Tenth Int. Geol. Cong., Mexico, vol. i, pp. 349–405, 1906.

Pleistocene time as the most significant transition epoch of the climatic history of the earth.

There seems to be a tendency in recent years to fall back upon the hypothesis of variations in the emissive power of the sun to account for the variations of surface temperatures indicated by ice formations.[1]

It is certainly quite possible and even probable that the sun's emission has altered within geological time, but neither the distribution of fossil life nor the evidences of ice formations occur with that zonal arrangement in harmony with solar-controlled climates, so that to the writer it seems necessary to attribute geological climates to a uniformly distributed source of heat, and to eliminate solar control by the reasonable assumption of persistent cloudiness. It is not implied that the clouds were so thick as to prevent the transmission of light such as is now received on overcast days, but a far less thick layer than that would suffice to screen off most of the solar-heating effects. Moreover, under the hypothesis that solar radiation was interrupted by a thin but continuous stratum of cloud, there is no reason why glaciers should not flow into the sea at any latitude.

When cloud densities decreased to approximately present conditions the tropical zones of downcast currents and minimum cloudiness were the regions first affected, and in these solar radiation first reached the surface. Thus solar radiation which, with a continuously cloudy sky, fixed the tropical zones as regions most exposed to cold downcast currents and to glaciation, also fixes them, with present cloudiness of 52 per cent. of the earth's surface, as regions of maximum exposure to solar radiation. The great continental glaciers of the northern hemisphere were grouped about the North Polar region for the reason that continents are so grouped, and for the additional reason that atmospheric circulation fixes latitude 50° N. as one of the belts of maximum storm circulation and precipitation.

Solar climatic control distinctly manifests itself by a zonal arrangement of temperatures and of life; under this control the disappearance of Pleistocene ice-sheets is taking place. The earth is therefore not in an era of senility or decrepitude, but in the springtime of a new life in which nobler, higher types of life are being developed.

The difficulties attendant upon the previous explanation of climatic phenomena appear to the author to be due to false premises, namely, (1) that solar radiation controlled the climates of Pleistocene and previous eras; and (2) that effective earth heat, under the extremely slow processes of loss and bringing into effectiveness and the powerful processes of conservation, was entirely lost prior to the era of zonally disposed climates. Upon a rejection of these assumed premises we may freely admit that ice has been a geologic agent from the earliest ages, particularly upon land masses of low specific heat and extremely low conductivity, and that the regions of cold downcast currents were, prior to the Pleistocene, most exposed to cold downcast currents and to consequent local glaciation; and that as the supply of earth heat fluctuated, ice formed under favourable conditions over large geographic areas in any latitude and during many eras, to disappear from an

[1] Professor David, Trans. Tenth Int. Geol. Cong., Mexico, vol. i, pp. 481–2, 1906.

increase of available earth heat or a lowering of elevation. These earlier ice formations were, however, not accompanied by cold seas, nor upon their disappearance were zonally distributed climates established.

The approaching, culminating, and succeeding phenomena of the Ice Age were therefore far more remarkable and significant than the corresponding phenomena accompanying the occurrences of ice as a geologic agent in the earlier ages. The worldwide distribution of cold temperate life just preceding the equally worldwide phenomena of Pleistocene glaciation, and the succeeding era of zonally distributed temperatures and life distinctly dominated by solar control, mark a profound change in the climatic history of the earth, and make it manifest that but once have the oceans chilled to that degree of cold which warrants the use of the term Ice Age.

Summary.—The phenomena of the earlier glaciations and the preceding, accompanying, and succeeding distributions of temperatures and of life appear to warrant the conclusions—(1) That these phenomena did not occur during eras of solar climatic control; (2) that there were apparently marked fluctuations in the amounts of available earth heat; (3) that during periods of deficiency and upon elevated areas, and particularly in zones of downcast atmospheric currents, local glaciers of great extent formed; (4) that these glaciations disappeared or varied from one of several causes, (*a*) accessions of heat from the crust, (*b*) variations in the elevation of the crust, (*c*) possible intermittent thinnings of the denser cloud formation of earlier eras in the regions of minimum cloud formation, permitting solar radiation to reach the earth's surface in these latitudes; (5) that these glaciations were not of the same order of magnitude nor did they mark the climacteric era of the evolution of climates as did the Ice Age.

II.—Royal Society.—The Lignite of Bovey Tracey. By Clement Reid, F.R.S., and Eleanor M. Reid, B.Sc. Read June 16, 1910.

In 1863 Heer and Pengelly published in the *Phil. Trans.* an account of these lignite beds and their flora. Heer classed the lignite as Lower Miocene, considering it equivalent to the Aquitanian of France and to the Hamstead Beds of the Isle of Wight. These latter are now referred to the Middle Oligocene.

A statement by Starkie Gardner, that Heer's Bovey plants are the same as those found in the Bournemouth Beds (Middle Eocene), has caused the Bovey Beds to be classed as Eocene in recent textbooks and on recent maps of the Geological Survey, leaving a great gap in the geological record in Britain. Our researches have not supported this view, but tend to show that Heer was right, the Bovey lignite being highest Oligocene, or perhaps lowest Miocene. We could find in the Bournemouth collection nothing to support Gardner's view, and he does not appear to have collected at Bovey, his comments referring to the collection now in the Museum of Practical Geology.

We therefore made a collection in the Bovey deposits, as far as the state of the lignite pit would allow, in order to settle if possible the true age. The results were unexpected, for by using new methods we obtained a considerable number of species, mainly identical with well-known plants of the lignite of the Wetterau, which is generally classed as Upper Oligocene. In certain cases better specimens showed also that Heer's supposed peculiar species of Bovey belong to well-known forms of the Rhine lignite—his *Vitis britannica*, for instance, being only a crushed seed of *Vitis teutonica*. Several curious new species were discovered, including the earliest known *Rubus*, a peculiar *Potamogeton*, and a new genus of Boragineæ.

A study of the cone and leaf of *Sequoia couttsiæ* proves that it is a true *Sequoia*, and not a species of *Arthrotaxis*.

III.—Edinburgh Geological Society.

A GEOLOGICAL work by Dr. Ogilvie Gordon, entitled *The Thrust-masses in the Western District of the Dolomites* in South Tyrol, has just been published by the Edinburgh Geological Society in a Special Part of their *Transactions*, vol. ix; price 7*s*. The text extends to 91 pages, and is illustrated by 2 geological maps, 18 coloured geological sections, and a number of original photographs and sketches. Mrs. Gordon describes a series of gigantic thrust-masses composed, in that district, of Permian, Triassic, Jurassic, and Cretaceous rocks that have travelled from east to west above the older crystalline rocks of the Central Alps, and have subsequently been downthrown along with the older rocks and suffered further deformation in the region of the Dolomites. The base of the series is composed of brecciated rock-material belonging to the floor over which the subjacent mass has passed and to the lower layers of the subjacent mass. The lower layers of each mass differ from place to place, as they were masses that had been already plicated in east and west direction, and in the course of the overthrust movements new plicational forms were superinduced both in north and south and in east and west directions. Similarly the cross-faults intersect, or coalesce with, the E.–W., E.N.E.–W.S.W., and W.N.W.–E.S.E. faults, and form fault-networks which completely isolate the adjacent areas in the crust. The chief Dolomite mountains, such as the Langkofl and Plattkofl Massive and Sella Massive, are areas of inthrow surrounded by faults, within which the higher thrust-slices have been preserved.

One of the geological maps shows four successive thrust-masses—(1) a basal thrust-mass mainly composed of the Permian Quartz Porphyry and Gröden Sandstones, the Lower Trias, and the *Calcareous facies* of Muschelkalk and Marmolata Limestone; (2) a thrust-mass comprising fragments of the older strata and widely extended exposures of the *porphyritic lavas and tufaceous and dolomite facies* of Middle Trias; (3) a thrust-mass belonging to the same facies as (2), but mainly composed of Schlern Dolomite, with varying thicknesses of the lavas and tuffs below it and of Upper Trias and younger horizons above it; (4) a thrust-mass mainly composed of Upper Triassic Dolomite associated with infolds of younger Mesozoic strata. The other geological map shows the detailed stratigraphy of the Langkofl and Plattkofl Massive. This mountain has been regarded as a 'Coral-Reef' of Middle Triassic age, but the supposed 'reef' peculiarities are interpreted by Mrs. Gordon upon the basis of the overthrust structures typical of the whole area. The outstanding deformational feature of all the thrust-slices is the rapid variation in the thickness of the various horizons of strata. Other features are the brecciated or nodular structure of the rock-material in the crush-zones, passing into gneissose and schistose structure, and the close cleavage penetrating the rocks in intersecting directions. The outward dip of the strata noticeable in the chief mountain-massives is a dip participated in by the subjacent thrust-masses and associated with steep flexures towards leading faults of the later period of downthrowing and horizontal displacements. Mrs. Gordon interprets the leading strike in the district as a curve round the north, west, and south, and the transversal directions as N.N.W.–S.S.E., N.–S., and N.N.E.–S.S.W., the system being essentially an interference system produced in virtue of the coalescence of plicational effects during the interaction of north-south and east-west pressures.

REVIEWS.

I.—The Sub-Antarctic Islands of New Zealand.

Reports on the Geophysics, Geology, Zoology, and Botany of the Islands lying to the south of New Zealand. Edited by Professor Charles Chilton, M.A., D.Sc., F.L.S. Published by the Philosophical Institute of Canterbury. 2 vols. 4to; pp. xxxv, 848. Wellington, N.Z. London: Dulau & Co., 1909.

THE observations recorded in these two volumes are the results of an expedition made in November, 1907, with the co-operation of the New Zealand Government, to the more important islands that lie to the south of New Zealand.

The geology of Campbell Island and the Snares is described by Professor P. Marshall and Mr. R. Browne, and that of the Auckland, Bounty, and Antipodes Islands by Mr. Robert Speight and Mr. A. M. Finlayson.

In Campbell Island the oldest rock formation is a mass of gabbro. Somewhat larger areas are occupied by oceanic limestone, with foraminifera, occasional grains of glauconite, some flints, but no detritus: it is regarded as probably of Miocene age. The main mass of the island is formed of volcanic breccias and lavas (trachyte, phonolite, and basalt), the terraced features being due to the outcrop of nearly horizontal flows of lava, separated by less resistant scoria beds. Abundant evidence of glaciation was observed, but the formation of glaciers on the island is regarded as the result of a general cause of refrigeration and not as specially due to elevation. The absence of raised beaches and rock-shelves indicates that there has been no recent elevation, but it seems probable that a movement of depression is in progress.

The Auckland Islands exhibit evidence of "a moderately severe glaciation", and there are indications that it was probably more intense at an earlier date. Considerable elevation of the land must have occurred during those times, but the upheaval is not regarded as having been a predominating factor in the glacial conditions. Nevertheless it is regarded as "reasonable that the Auckland Islands were at least 7000 feet high". The land now attains an elevation in places of more than 2000 feet, so that the uprise would have been 5000 feet or more, and would "go far to explain the connexion of New Zealand with a former antarctic continent". The main island of Auckland is mostly formed of basalt of middle or late Tertiary age. An older basic series, also conglomerate, which may represent an ancient river-bed, and trachytes, occupy smaller areas. Over more limited tracts there are exposures of granite and gabbro, the actual and relative ages of which are undetermined.

The rocky islands and islets of Snares and Bounty are formed of granite. Of the Bounty Islands it is remarked that "The rocks near sea-level are worn smooth not only by the action of the breakers, but also by the polishing action of the feet of the seals and millions of penguins and other sea birds, which make the island their breeding-place. The general rock-surface is as slippery as glass, and exceedingly difficult for man to travel over. Immense quantities of guano are deposited on the islands during the breeding season, but during winter storms it is swept off, with the exception of that which accumulates between the boulders".

Campbell Island and the Snares are much covered with peat, and there is a separate article on the soils and soil-formers, by Mr. B. C. Aston.

The main features of the islands are represented in a number of photographic illustrations and maps, and the rocks are illustrated by micro-sections. The entire work may be regarded as a substantial contribution to our knowledge of the natural history of these sub-Antarctic islands, with full references to the work of previous observers.

II.—Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for 1909. pp. iv, 92, with 5 text-illustrations. London: printed for H.M. Stationery Office, 1910. Price 1*s*. London, W.C.: T. Fisher Unwin.

The important announcement is made by the Director, Dr. J. J. H. Teall, that the Survey of the South Wales Coal-field and that of the Derbyshire and Nottinghamshire Coal-field, on the 6-inch scale, have been completed, the work in the latter case having been connected with that carried out many years ago in the Yorkshire Coal-field by A. H. Green and colleagues. We learn also that the 6-inch field-work in Cornwall and Devon has been completed so far as at present contemplated. It is to be noted with regret that the name of the Director does not appear in the Summary; it was omitted also in the Summary for 1908. Such an omission is opposed to the prevalent notion that a man is responsible for the work he undertakes, and it is likely to give considerable trouble in the future to biographers and bibliographers. The policy of the Board of Education in omitting the names of the chief officers who contribute reports of the work of their departments to the General Report of the Board, is again a very inconvenient and unjustifiable piece of "red tape".

In Scotland the mapping of Ben Nevis has led to the conclusion that the volcanic rocks which form the higher part of the mountain are of Lower Old Red Sandstone age, and that they rest on Highland schists which are almost entirely concealed by bordering granites. The structure of this region forms the subject of a separate article by Mr. H. B. Maufe.

A short but important article is contributed by Mr. C. T. Clough on the stratigraphical relations between the Red Barren Measures and the Productive Coal-measures of Scotland. He states that there is no evidence of any break of importance between these divisions, and that consequently wherever the Upper Red Carboniferous strata occur, the Productive Measures may be expected beneath them. Mr. C. B. Crampton describes a Manganese deposit near Freswick, Caithness; Dr. W. Gibson gives an account of three borings in the Ingleton Coal-field; and Mr. John Pringle gives further particulars of a boring at Stowell, Somerset, that was carried through the Fullers Earth into the Sands beneath the Inferior Oolite. It is a remarkable fact that 25,000 gallons of water a day were obtained from the Fullers Earth Rock, and that the lower strata yielded no supply. Lists of fossils are given from the Inferior Oolite Series.

In the accounts of the progress of the field-work in the different districts of England, Wales, and Scotland there are records of many interesting observations on most of the geological formations from the Ordovician to the Lias, on Tertiary including the Bovey Beds, on Pleistocene and Recent deposits, as well as on the Highland schists, on certain supposed pre-Cambrian rocks (the Johnston Series) in Pembrokeshire, and on various igneous rocks. Analyses are given of clays from the Bovey Basin and from the Marland Clay Works, Torrington.

III.—Geology in the Field. The Jubilee Volume of the Geologists' Association (1858–1908). Edited by H. W. Monckton and R. S. Herries. Part IV. pp. 661–896, with 14 plates. London: Edward Stanford, 1910. Price 5*s*. net.

With the exception of a general and copious index which "will be ready shortly", the elaborate Jubilee Volume is now complete.

The present number opens with an article on "Northumberland and Durham", by Professor E. J. Garwood. After remarking on the scenery and tectonic features, the author gives a brief account of the Silurian, which is not known to include strata higher than the Wenlock Series. The unconformable Lower Old Red Sandstone with its andesitic lavas is next described, together with the intrusive rocks (granite and porphyrite) which indicate later phases of igneous activity. Upper Old Red Sandstone is doubtfully recognized in certain conglomerates at Windy Gyle, as the strata have been regarded by some geologists as basement Carboniferous. The various divisions of the Carboniferous and the palæontological horizons are duly described; and the author draws attention to the occurrence, apparently near the base of the

Yoredale Series, of *Posidonomya Becheri*, which is characteristic elsewhere of the Pendleside Group. The Permian beds are then dealt with, and it is noted that the Magnesian Limestone is succeeded conformably by Triassic red sandstones and marls—beds which, curiously enough, have been regarded as Keuper by some authorities. The important sills and dykes of post-Carboniferous date and the Glacial and newer deposits finally receive attention.

The second article is on "The Malvern and Abberley Hills, and the Ledbury District", by Professor T. T. Groom, who gives a summary of his detailed researches on the tectonic structure of the region, together with concise accounts of the Archæan and the fossiliferous Cambrian, Ordovician, and Silurian rocks. Special attention is given to the subdivisions of the Silurian, and a valuable list of fossils, showing the range of the species from the May Hill Sandstone to the Upper Ludlow, is appended.

"Shropshire" forms the subject of the third article, and is happily dealt with by Professor Lapworth. Brief accounts are given of the several types of pre-Cambrian rocks, the Rushton schists, the granitic and gneissose rocks, the Uriconian, and Longmyndian. It is remarked that the term Uriconian has been applied to certain disconnected groups of ashes and lavas, and in a table showing the apparent descending sequence of the lithological groups in Uriconian and Longmyndian the author has been led to place at the top the Linley volcanic series, equivalent to the Western Uriconian of Callaway, and at the base the Cardington volcanic series or Eastern Uriconian of Callaway. The intermediate groups of Western and Eastern Longmyndian are ranged under eight subdivisions. This classification, based on Professor Lapworth's detailed field-researches, will be of immense service to future workers. The Cambrian rocks are briefly described, and the various local divisions established by the author in the Ordovician system again give information of special importance. Then follow accounts of the Silurian divisions, and brief descriptions of Carboniferous and newer formations, of tectonic geology and physiography.

The fourth article, on "Charnwood Forest", is naturally written by Professor W. W. Watts, whose elucidation of the complex structure and of the nature of the buried mountain mass has been a great achievement. Preserved beneath a cover of Keuper Marl, the erosion of this newer deposit has revealed portions of what the author terms "the fossil Triassic landscape of Charnwood".

In the fifth article Mr. W. G. Fearnsides gives an account of the main features in the geology of "North and Central Wales". Rocks from pre-Cambrian to the Old Red Sandstone, sedimentary, volcanic, and intrusive, are duly described, attention being given to the prominent and characteristic fossils and to the method of formation of the strata. It is noted that the Old Red Sandstone is locally continuous in all respects with the Downtonian. The author then discusses the general structure of the area and the various great earth-movements that have taken place, and in a series of diagrammatic sections he illustrates his views on the more important stages in the building of Wales from the Uriconian era to the present day.

In the sixth article, by Dr. A. Strahan, "South Wales" is dealt with, mainly so far as the region has been visited by the Geologists' Association. Thus the oldest rocks described are the Silurian near Cardiff and in Gower. Attention is directed mainly to the Old Red Sandstone and Carboniferous rocks, the Trias and Lias, the Raised Beach and Caves of Gower, and the Glacial and post-Glacial deposits, concerning all of which is given a summary of the latest information, much of it acquired by the author during the progress of the geological survey. The intimate connexion between the Rhætic beds and underlying Keuper Marls, manifest from the stratigraphic and palæontological evidence noted by the author, is not, however, recognized by him, and his views differ from those of other writers in the Jubilee Volume (pp. 332, 491, and 863). In a final section on Physiography the author discusses the relations of the river-systems to the geological structure.

The seventh and final article, on "Cornwall, Devon, and West Somerset", is by Mr. W. A. E. Ussher, who has given accounts of a great series of formations from the most ancient rocks of the Lizard to the Pleistocene and Recent deposits. His table of strata and of igneous rocks, indeed, extends over more than two pages, and his task of summarizing the information on this varied series must have been an exceedingly difficult labour of love.

The igneous rocks and the China clay are first dealt with; then follows an account of the Lizard from the pen of Dr. J. S. Flett, who gives some of the results of his recent investigations on this complex group of mica-schists, quartzites, granulites, hornblende-schists, serpentine, gabbro, dolerite, and granite. The various schists of Start, Bolt, and Prawle are next described, and the author takes a "non-committal attitude" regarding their age. The results of recent work on the small areas of Ordovician and Silurian and on the Devonian and Carboniferous rocks form the most important portion of the author's article. As he intimates, a good deal remains to be done before the grouping and relationship of all the divisions of Devonian and Carboniferous are determined. While he hesitates to accept Hicks's view of the age of the Morte Slates, as the field-evidence does not favour the intercalation of Lower Devonian in the area where the Morte fossils were found, yet, as he remarks, "detailed mapping on the six-inch scale may vindicate Hicks's view."

The New Red Rocks and later deposits are described, some very briefly, but with special reference to recent researches.

IV.—Yorkshire Type Ammonites. Edited by S. S. Buckman, F.G.S. Parts I and II, pp. i–xvi, with 24 plates and descriptions. London: William Wesley and Son, 1909 and 1910. Price per part 3*s*. 3*d*. net.

The object of the present work is to give descriptions and illustrations of the Jurassic Ammonites that were named by Young & Bird and by Martin Simpson. It is remarked that the type-specimens of which sketches without descriptions were published by John Phillips are lost; but the majority of the specimens described and illustrated by Young & Bird, and those described (but not figured) by Simpson, are preserved in the Museum at Whitby. The Editor expects to deal with 150 or more species, and to complete his work in about sixteen parts, each containing from twelve to sixteen plates. The original descriptions of the fossils are reprinted, together with figures of the types admirably reproduced from photographs, mainly by Mr. J. W. Tutcher.

Of special importance is the illustration of the Simpson Collection. The specimens, as the editor remarks, had received "careful and discriminative studies", but without figures "it is almost impossible to obtain due knowledge of Lias Ammonites, and certainly dangerous to describe or name species as new". In identifying and figuring Simpson's species he has rendered a distinct service to palæontology. Simpson, although ready to add, where necessary, to the number of species, was averse to the multiplication of genera, and in this he will have the cordial sympathy of most geologists.

The editor gives definitions of biological, biogenetic, and other technical terms, also some notes on Ammonite development and on generic names. It is a defect that all the new names have not the suffix *ceras*, surely a convenience even for the palæo-biologist, who, as a rule, can alone find use for them; but the editor is by no means entirely responsible for this. He gives the latest of the generic Ammonite names, and a list of comparable species with references. This list is admittedly incomplete, but it might well have included all the names adopted by J. F. Blake.

Among the forms figured are *Ammonites mulgravius*, *A. exaratus*, *A. levisoni*, *A. lythensis*, and *A. lenticularis*; also one Nautilus, *N. subcarinatus*. To the ordinary geologist a Nautilus, however, is not an Ammonite. We trust that the editor will be well supported in his undertaking.

V.—Brief Notices.

1. Yorkshire Fossils.—Messrs. H. C. Drake & Thos. Sheppard have published in the Proceedings of the Yorkshire Geological Society, vol. xvii (1), 1909, a "Classified List of Organic Remains from the Rocks of the East Riding of Yorkshire", post-Glacial to Lias. This laborious piece of work aims at "placing in a convenient and compact form all the various and scattered records that have been published". No attempt has been made to revise the nomenclature, as it was felt that the older names would be more familiar to searchers. It is now easy to ascertain whether a given species has been previously recorded, and the reference to the authority and the place of publication have been indicated.

2. Department of Mines, Canada.—The Summary Report of the Geological Survey Branch of the Department of Mines, Canada, for 1909, issued 1910, contains much useful information on various subjects and localities. In his Report the Director, Mr. R. W. Brock, remarks that although the work undertaken by the Survey has been along strictly economic lines, the geologists are not engaged in prospecting. Thus "The Government geologist may recognize and direct attention to mineralized districts that afford promising ground

for prospecting, and furnish information regarding the geological conditions and mode of occurrence of minerals, that will form serviceable guides to the prospector; but only rarely can a geologist, engaged in his legitimate work, actually discover important bodies of economic minerals". He rightly observes that "Negative results are, in their way, quite as valuable as positive", inasmuch as they discourage fruitless enterprise. Some important discoveries, however, have been made of coal-bearing strata in the Whitehorse district and in Alberta. Reports on the Yukon Territory are included, and it is remarked that the conditions in the Stewart River district appear to be favourable for placer mining. The results of borings on Prince Edward Island prove that Carboniferous rocks do not occur within 2000 feet of the surface.

Since the death of Dr. J. F. Whiteaves, the Palæontological work has been carried on by Mr. Lawrence M. Lambe, aided by Mr. W. J. Wilson.

A separate Annual Report of the Division of Mineral Resources and Statistics on the Mineral Production of Canada is published by the Department of Mines; that for the two years 1907 and 1908, by Mr. John McLeish (issued 1910), includes particulars relating to metallic ores and non-metallic products. Among the latter are abrasive materials, asbestos, coal, peat, gypsum, mineral water, natural gas, petroleum, and salt.

We have received copies of two separate Geological Survey memoirs—*A Reconnaissance across the Mackenzie Mountains*, by Mr. Joseph Keele, 1910; and *Geology of St. Bruno Mountain, Province of Quebec*, by Mr. John A. Dresser, 1910.

CORRESPONDENCE.

MARSUPITE CHALK IN SURREY.

Sir,—About two years ago I recorded the discovery of the *Uintacrinus* Chalk at Orpington, Kent. During the summers of the following years I traced this zone through Holwood Park to West Wickham, and also succeeded in finding the Marsupite zone in these last-named localities. Throughout the same period I also worked the roadside chalk at Farnborough Hill without any definite result. In June of this year I turned my attention to the chalk in the lane leading from Farnborough to High Elms, having a strong suspicion that this band of chalk would prove to be connected with Orpington and Holwood Park. My efforts were quickly rewarded, and in three visits I secured a characteristic fauna and numerous plates and arm-ossicles of *Marsupites* from the upper end of the lane. I hope subsequently to publish the results of these and other workings during the past few years.

G. E. Dibley.

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Lower Sydenham, S.E.

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OCTOBER, 1910.

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THE

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No. X.—OCTOBER, 1910.

ORIGINAL ARTICLES.

I.—The Structure of Glaciers.

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

IN August, 1841, Professor J. D. Forbes, in company with Professor Agassiz and Mr. Heath, spent some time upon the Lower Glacier of the Aar, and Forbes states that it was then for the first time that he noticed the veined or ribboned structure of glaciers. Although the description given in the communication he made to the Royal Society of Edinburgh in December of the same year is most interesting, he does not state clearly how the structure is related to the glacier grains of which the ice streams are built up.

During the several visits I have paid to Switzerland for the purpose of studying the structure of glacier ice the relationship between the form and size of the ice grains and the superficial effects produced by their weathering have been carefully noted.

Except at high altitudes the granular structure of the ice can only be properly studied in the ice caves which have been excavated for the attraction of tourists. At low levels the glacier surface is much disintegrated by the warm air and sun, and its appearance will be found to depend upon the size and shape of the glacier grains or the inclusion of air bubbles. Although Forbes frequently speaks of the veined or ribboned structure as though they were one and the same thing, the ribboning is rather a feature of the glacier surface when the veining is well developed.

Stratification.—In cases where the vertical unweathered faces of glaciers are exposed, such as those which are formed by the breaking away of the ice of hanging glaciers, the ice is seen to be horizontally stratified, the white layers being those portions of the ice which contain an excess of air bubbles imprisoned in the mass.

If the surface of the *névé* were always in a powdery loose condition at the surface it is likely that, as the mass became consolidated, the air would be almost wholly expressed and very blue clear ice would be formed. Glaciers, where clean vertical surfaces are exposed, vary much as regards blueness, the air bubbles where they are numerous making the ice appear more or less white in appearance.

The transformation of the snow into ice is the result of the slow growth of some crystals and the disappearance of others, and to the viscosity of the crystals in a direction at right angles to their optic axes. The consolidation must also be facilitated by the slow melting of the points of contact of granule with granule, due to the lower melting-point of the more stressed portions. Time is therefore an important consideration, as also is temperature, in the process of the consolidation of snow consisting of a great number of ice spicules, etc., into glacier ice consisting of a much smaller number of large crystalline grains.

The Antarctic Great Barrier, Professor T. W. E. David says, is composed of highly compacted snow rather than glacier ice. From measurements of the snowfall on it and the rate of flow he concludes that the ice at the depth of 900 feet at the Barrier face is only 900 years old. As the visible face is only about 120 feet high the oldest ice seen is therefore 120 years. To what extent the snow has really been converted into glacier grains we are as yet unable to say. It, however, clearly contains a very large number of air bubbles which give it the appearance of compacted snow and much reduce its density.

In most instances the *névé* surface is melted by the sun or warm air. In this way more or less impervious layers of ice are formed, which prevent the escape of the imprisoned air.

One of the first impressions produced on the mind on entering an ice cave is the solidity and blueness of the ice. One, however, soon notices white discontinuous layers, generally roughly parallel with the glacier bed, but much twisted and broken. These are the stratifications produced in the *névé* by the imprisoning of air bubbles.

Although the mass of the ice consists of glacier grains of all sizes and shapes the bubbles bear no relationship to either the size or the arrangement of the grains. The great majority of the bubbles are enclosed in the ice granules. Only occasionally are they seen at the interfaces. It would seem that as the crystals grow or decrease in size and the positions of the interfaces alter the bubbles are not displaced.

It is only at great elevations, where ice falls from hanging glaciers and thus exposes fresh clean surfaces, or in ice caves that I have seen the regular stratification due to imprisoned air. In the *névé* it is very clearly marked, but lower down in the glacier the differential motion, the opening and closing of crevasses, etc., give rise to great distortion of the white layers.

Veining.—A careful examination of the walls of an ice cave will reveal the fact that the glacier consists of an agglomeration of ice granules, the outlines of the granules being clearly defined by the delicate lines on their surfaces or the melting along the lines of contact. If a thin piece of notepaper be placed against the ice and the surface of the paper be rubbed with a pencil a rough copy of the surface markings is obtained. The granules vary in size very much, the glacier being composed of beds of granules of varying coarseness.

In a paper communicated to the Geological Magazine by Mr. G. Fletcher and the author we say "the veining resulted partly from the arrangement of the crystal grains and partly from a variation in the shape of the grains and partly from variations in their dimensions".

Except in ice caves, the very deep portions of crevasses, or beneath the moraines or large stones on the surfaces of the lower glaciers the ice is seldom seen in its blue compact condition. The effect of the sun upon the surface of a glacier is to break up the compact ice into loose crystalline granules. The principal effect of the sun is therefore to separate the granules by melting them at their interfaces. It is not necessary to postulate the presence of sodium salts in the ice to account for the rapid melting at the interfaces. At the interfaces the molecules are in an abnormal condition of strain, and are more easily set free (melted) than are those in the interior of the granules. Many of the interfaces are the result of slow shear without fracture bringing part of one grain against another, and in such cases there is surely no likelihood of the presence of foreign salts.

When not subjected to severe strains the larger ice granules grow in size at the expense of the small granules, which disappear. Where the strains are great, however, the large granules are broken up into smaller ones again. This breaking up of the granules occurs in layers of more or less considerable thickness in directions parallel with the motion of the glacier, which thus becomes composed of layers of granules of varying coarseness. The heat of the sun shining on the glacier disintegrates the grains, and the smaller these are the whiter the glacier surface appears, and the larger they are the bluer the surface appears. A large transparent bluish crystal, for instance, if broken up will form a white powder. The blue and white veins seen on the surface of a glacier and passing near the sides of the glacier stream almost vertically down the walls of the crevasses, are due to the disintegration of layers of granular ice of varying coarseness. That this is the case I have proved by cutting away the disintegrated white surface until firm blue ice was reached, and by examining the granules below blue and white veins.

Ribboned structure.—The veined and the ribboned structures are generally so closely associated that they were dealt with by Forbes as one structure. We will leave Forbes to describe this feature in his own words. "I noticed in some parts of the ice an appearance which I cannot more accurately describe than by calling it ribboned structure, formed by *thin* and delicate blue and bluish-white bands or strata, which appeared to traverse the ice in a vertical direction, or rather which by their opposition formed the entire mass of the ice. The direction of these bands was parallel to the length of the glacier, and of course being vertical they cropped out at the surface . . . Not only did we trace them down the walls of the crevasses by which the glacier is intersected, as far as we could distinctly see, but, coming to a great excavation in the ice, at least 20 feet deep, formed by running water, we found the vertical strata or bands perfectly well defined throughout the whole mass of ice to that depth." It is these vertical strata or bands which run mainly in or near the white veins which I regard as the ribboned structure. Neither these ribbons nor the white and blue veins should be confounded with the stratification of the *névé* due to air bubbles. The ribboned structure, and also the veining when seen near the sides of the glacier, is generally more or less vertical, but in the Mer de Glace, etc., the structure may be seen to curve round and cross the centre of the glacier, forming great loops directed down-stream. The veining and ribboned structure are nearly parallel with the sides and bottom of the glacier, and where the surface is being rapidly melted the lower horizontal veins near the middle come to the surface and form these loops. Forbes appears to be quite correct when he says "the vertical structure is too close to the original strata of the *névé* to allow of the supposition that these have all of a sudden turned up vertically in some parts of the glacier, and disappeared in the remainder".

In the cave which was made in the lower portion (which has now melted away) of the Upper Grindelwald glacier I have seen the ice built up of more or less regular layers of flat ice granules, the whole appearing like a mass of masonry or ribbons of grains. The shear-planes cutting the granules and giving rise to this ribboning are produced by slow shear without fracture parallel to the direction of flow. This regular structure produced by shear is not commonly seen in ice caves, for they are generally excavated at the ends of glaciers where the rate of distortion is small. Where this masonry-like structure crops out on the glacier it discloses itself as ribboned structure. As before remarked it is generally parallel with the veined structure, and seems to make it more striking. On the Rhone glacier the ribboned structure is shown up by the dirt which settles in the parallel fissures produced by the melting of the ice along the shear-planes. Where streams cut into the ice it is frequently well shown.

Both the veined and ribboned structure will be found most perfectly developed when the glacier is moving rapidly and the internal strains, i.e. rate of distortion, is greatest. When a glacier widens, becomes thin, or for any reason moves slowly, the slow alterations which are constantly taking place in the shape of the grains gradually obliterates the structure. Owing to the motion the structure is also carried to portions lower down the glacier than those where it is being produced, and in crevassed areas the veins and ribboned structure are twisted about in a very striking manner. The time required for the grains to appreciably alter their form and size must be measured in years.

II.—On the discovery of Bembridge Limestone Fossils on Creechbarrow Hill, Isle of Purbeck.

By Henry Keeping, Sedgwick Museum, Cambridge.

(PLATE XXXIV.)

When last year I had an opportunity of examining a few rocks and fossils from the limestone of Creechbarrow Hill, which the late Mr. W. H. Hudleston considered of Bagshot age, I at once suspected that they belonged to the Bembridge Limestone. Upon my pointing this out to Professor Hughes he requested me to go down to examine the ground, which I did in November of last year, but I found only the same fossils which Mr. Hudleston had recorded, namely, *Melanopsis* and *Paludina*. On my return to Cambridge I expressed the opinion that better evidence would probably be obtained if a few openings were made here and there, and the Professor arranged that

I should carry out a further examination of the area at a more convenient season. This I have done, and I now offer the results of my further researches.

After getting permission from the owner of the land, G. W. Bond, Esq., and his tenant, Mr. Trent, I commenced by making an opening on the south side, and also spent some time in the pit which Mr. Hudleston had made, but I found only the same fossils as on my last visit. Feeling sure that the limestone must be found at a lower level I opened another pit, about 12 feet long, at the base of the limestone. At one end of this pit I found a reddish marl called by the workmen Cherry Marl, which I refer to the Osborne formation. Few or no fossils are ever found in this marl. At the end nearest the top of the hill we came on the base of the limestone resting on the marls. I recognized the section as exactly similar to that in which the vertebrate remains were found in the Isle of Wight, and examined it carefully. In about ten or twelve minutes I found part of the tooth of a *Palæotherium*. Unfortunately I had only about a yard of this bed exposed, but I feel sure from the character of the deposit that more mammalian remains might be obtained here. I then opened

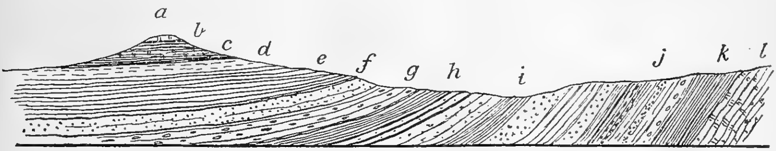


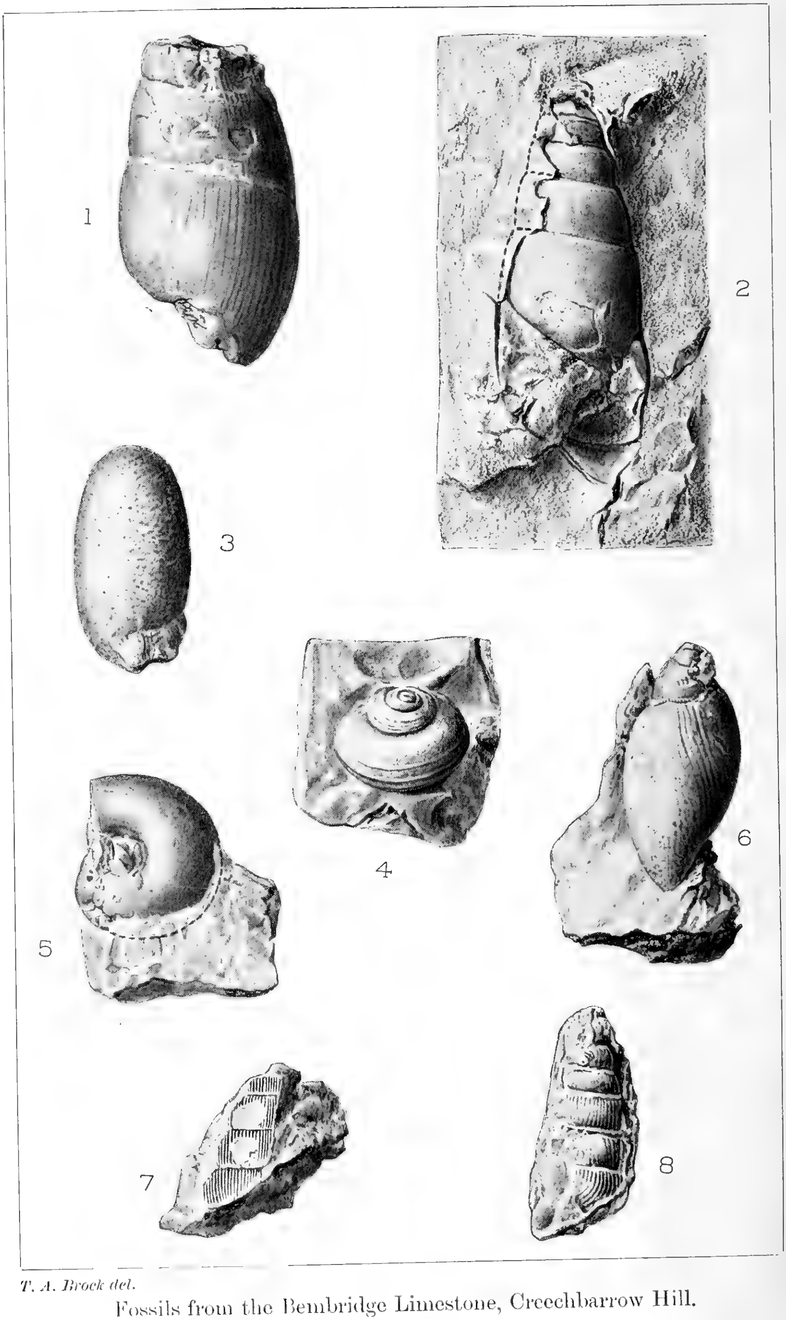
Diagram Section showing the relation of the Creechbarrow Limestone to the underlying series: *a*, Bembridge Limestone; *b*, Osborne Series; *c*, Upper Headon Series; *d*, Middle ditto; *e*, Lower ditto; *f*, Sands; *g*, Barton Beds; *h*, Bracklesham Beds with lignite; *i*, Bagshot Beds with pipeclay; *j*, London Clay; *k*, Woolwich and Reading Beds; *l*, Chalk.

another pit on the north side of the limestone, and after reaching a depth of about 7 feet I found what I had been looking for, namely, beds of limestone which I would refer to a lower horizon in the Bembridge Series. These yielded good results, as I obtained from them *Bulimus* (two species), *Cyclotus* (two species), *Helix* (two species), *Clausilia* (two species), *Achatina costellata*, and the so-called eggs of *Bulimus*: altogether about twenty species, some of which have not yet been determined. The marls in the old excavations, still to be seen some way down the hill-side, which were explained by Mr. Hudleston as due to the crumbling away or waste of the limestone from the top of the hill, I believe are part of the Lower Headon Series, from which marl was formerly dug for manuring the land. A good dressing of this was supposed to last from seven to ten years. The marl of Creechbarrow is, however, much more sandy than any I have seen in the corresponding beds elsewhere. When I was a boy of seven or eight years of age I should say there could not have been less than fifty men employed at this work. I have many times watched them digging, and they occasionally turned up portions of the freshwater and mud tortoises *Trionyx* and *Emys*.

This marl has an extensive range and may some time be of use again; it extends from Whitecliff Bay to Headon Hill, by Hordle, Lymington, Brockenhurst, and Lyndhurst, and various other places in the New Forest; it is then lost until we reach Creechbarrow Hill, where we find it again in the disused marl-pits referred to above. At Cut-walk Hill, where it was once extensively worked, a part of the Middle Headon Series is passed through before reaching the marl. At the base we frequently find specimens of the beautiful little *Voluta geminata* and other marine shells. Sir Charles Lyell when a young man of about 17, crossing a field with some sportsmen, picked up several of those fossils, and about twenty years afterwards sent specimens to F. E. Edwards, who was then preparing his Monograph on the Eocene and Oligocene Mollusca. I was at that time living at Milford, and Mr. Edwards wrote asking if I would try to find the locality. This I did, and made a good collection of fossils from Cut-walk Hill, one mile and a half north of Lyndhurst. The Rev. O. Fisher and the Rev. John Compton, Rector of Lyndhurst, visited the localities with me and collected a considerable number of fossils. Sir Charles Lyell, Professor Prestwich, and Sir W. H. Flower also visited the place for the purpose of studying the formations. The Rev. O. Fisher will, I am sure, corroborate my statements respecting the digging of the marl and the finding of the fossils at Brockenhurst, Lyndhurst, and elsewhere in that district.

This, I believe, is the first time that the Oligocene formation has been shown to occur in the Isle of Purbeck, and it will now be seen that it had a much more extensive range than had previously been supposed. Beginning at Whitecliff Bay it runs across the larger part of the parish of Bembridge, over the Solent to Hordle, Lymington, Beaulieu, Brockenhurst, and Lyndhurst, and extends thence to Creechbarrow Hill, about 7 miles west of Studland Bay. When engaged in making a collection for the Marchioness of Hastings, I found at Efford Hill a disused marl-pit quite rich in vertebrate remains, and I there collected portions of a crocodile's jaw with teeth, various mammalian remains, with *Emys* and *Trionyx*. These specimens are now preserved in the British Museum (Natural History), South Kensington. The marls which are found between the 400 and 500 foot contour-lines I regard as Lower Headon, and are the same as those which were formerly so extensively worked for manuring the land. It can now be seen that if we allow this to be Lower Headon we have space enough between it and the top of the hill for the Middle and Upper Headon, the Osborne, and the Bembridge Series. By taking the average level of the Pipeclay Series, say at the 337 foot contour, we shall leave 300 feet to the top of the hill, and allowing 50 feet as the thickness from the Pipeclay to the top of the Lower Bagshot Series, we shall have 250 feet for the Bracklesham, Barton, and the whole of the Oligocene; from which it will be seen that the hill may contain all the formations which occur in the corresponding position in the Isle of Wight.[1] The sand and flints described by Mr. Hudleston, and

[1] The only formations which have not been satisfactorily proved to occur are the Bracklesham, the Barton, and the Middle and Upper Headon. I have no doubt that those could be found in the hill by the sinking of pits and perhaps of a few boreholes.



T. A. Brock del.

Fossils from the Bembridge Limestone, Creechbarrow Hill.

considered by him to be of Lower Bagshot age, I regard as Pleistocene drift, such as may be met with in many places, not only in the Isle of Purbeck, but in the New Forest and the Isle of Wight. At the Rabbit Warren at Headon Hill there is nearly or quite 100 feet of sand and flint gravel, the flints being in every respect exactly similar to those from Creechbarrow. One of the workmen picked up, at a depth of about 13 feet, in one of the pits a piece of Bembridge Limestone associated with the flints in the gravel, which is quite conclusive evidence that the gravel cannot be of Bagshot age.

In conclusion, I should like to thank Mr. A. H. Bloomfield for valuable assistance, and to assure any persons visiting the Isle of Purbeck for the purpose of studying its stratigraphy or collecting fossils that they would do well to secure his services.

EXPLANATION OF PLATE XXXIV.

Fossils from the Bembridge Limestone of Creechbarrow Hill, Purbeck, in the Sedgwick Museum, Cambridge, collected by H. Keeping.

FIGS. 1, 2. *Amphidromus* [*Bulimus*] *ellipticus* (Sowb.). 1, with shell preserved; 2, internal cast.
,, 3. Egg of *Amphidromus* (?).
,, 4. *Cyclotus cinctus*, Edwards; × 1½.
,, 5. *Helix occlusa*, Edwards.
,, 6. *Glandina* [*Achatina*] *costellata* (Sowb.).
,, 7, 8. *Clausilia striatula*, Edwards. 7, natural external cast, × 1½. 8, wax impression of external cast, × 1½.

III.—The Residual Earths of British Guiana commonly termed 'Laterite'.

By Professor J. B. Harrison, C.M.G., M.A., F.G.S., F.I.C., assisted by K. D. Reid, Assistant Analyst British Guiana.

On pages 20–2 and 99–105 of the *Geology of the Gold Fields of British Guiana* I gave a condensed account of the residual earths derived from the gradual decomposition of igneous rocks in situ which characterize wide areas in British Guiana as well as in the neighbouring countries of Venezuela, Dutch Guiana, French Guiana, and Brazilian Guiana. This deposit forms in many places a widespread very thick blanket-like coating to the igneous rocks from which it is derived, and owing in many places to its striking resemblance in general properties to the typical Indian formation described by Buchanan in 1807 it has been alluded to by many authors and by numerous mining engineers as 'laterite'. I gave on p. 101 two analyses of lateritic deposits which I selected from many I had made as showing the general composition of the earths. Unfortunately I omitted to show in them separately, as I had done in the original analyses, the proportions of silica present as quartz and of that present in a combined state. If I had done this it would have been seen that the earths contained but little combined silica and a relatively high proportion of alumina presumably present in the state of hydrate. For instance, in the Tumatumari sample which I collected myself from a deep cutting in the laterite lying on the diabase of the Tumatumari cataracts a few feet only above the surface of the unaltered rock, out of 51·76 per cent. of silica 49·35 is in the form of quartz, leaving 2·41 per cent. in the combined state in the presence of 24·55 per cent.

of alumina. I drew attention to this in a report on the soils of the interior of British Guiana published in 1902 in the following words: "A very large proportion of the alumina present is in the form of the hydrate, bauxite." As in the work on the Geology of the Gold Fields I was not dealing with the question of the presence of free alumina in the decomposition products of igneous rocks, but with the movements, the segregation, and the concentration into grains of the gold originally disseminated in certain of them, I contented myself by giving a reference to the full account and discussion of the Guiana laterites in Dr. G. C. Du Bois' monograph "Beitrag zur Kenntnis der Surinamischen Laterit", which was published in 1903 in *Tschermak's Mineralogische und Petrographische Mitteilungen.* A reference to this work would have shown that aluminous masses occur in the laterites of the Guianas and in Surinam, more especially in the re-arranged detrital deposits classed by Du Bois as "alluviale laterite". Unfortunately a reviewer of the work in the Imperial Institute Bulletin, vol. vii, No. 1, 1909, did not realize my object in thus referring to Du Bois' monograph, and therefore made unfavourable comments on my use of the term 'laterite', which term he stated "should be restricted to that product of weathering in hot moist climates which contains free aluminium hydroxide".

His comments have given rise to the recent correspondence between Mr. J. B. Scrivenor and Mr. T. Crook, in which the latter writes somewhat scathingly of "some people", amongst whom I am not ashamed to be included, who use the term laterite in the wide sense it is at present very largely employed by technical geologists, mining engineers, and tropical agriculturists. But in my opinion Mr. Crook is too severe in his strictures, strictures which appear to be based on a somewhat restricted view of the nature of the deposits in question, on the assumption that they mainly consist of masses of hydrated alumina—bauxite, gibbsite, or diaspore, or mixtures of them—which actually occur only in places in laterite; and I am quite unable to agree with him that the application of the term to such clays, iron-ores, etc., as I used it for is "wholly unwarranted", and that my use of the term is "unscientific" and one that "cannot properly be adopted by geologists". The British Guiana deposits are "a complex product . . . characterized by the presence of hydrated alumina, but usually containing also notable amounts of titanium and iron oxides, whilst free silica is generally present and hydrate of silicate of alumina is not necessarily absent", and the following account of these deposits formed by the decomposition of igneous rocks in situ and in some of which in parts hydrated alumina occurs may be of interest.

As far as my experience goes, the presence of free alumina in quantity in the residual earths resulting from the decomposition of igneous rocks in British Guiana characterizes rocks the felspars of which are mainly of the albite-anorthite series, whilst the residual deposits from rocks in which alkali-felspars such as orthoclase, anorthoclase, microcline, and albite are predominant, consist largely of kaolinite or of sericitic micas with kaolinite.

The general compositions of the soils found in aluminous lateritic areas are shown in the following analyses:—

Table I.—ANALYSES OF LATERITE SOILS.

Locality.	Rock whence derived.	Loss on Ignition.	Gravel.	Quartz Sand.	Clay, Silica, and Insoluble Silicates.	Iron Peroxide.	Alumina.	Manganese Oxide.	Calcium Oxide.	Magnesium Oxide.	Potassium Oxide.	Sodium Oxide.	Phosphoric Anhydride.
Mazaruni River—													
Hiamaraka Creek . . .	Gabbro	10·01	nil	18·40	36·86	11·23	22·56	nil	·22	·10	·01	·57	·04
Hiamaraka Hill . . .	,,	6·43	57·00	9·89	4·83	10·57	10·60	·06	·06	·06	·01	·02	trace
Barima River—													
Arakaka	Diabase	5·45	37·60	23·05	21·40	7·32	4·92	·06	·16	·16	·02	·03	trace
Potaro River—													
Tumatumari	Diabase (dolerite)	11·18	nil	49·35	3·08	11·34	24·55	nil	·23	·21	·21	·14	trace
Potaro Landing . . .	,,	6·89	5·70	19·10	58·40	4·76	5·11	,,	·05	·05	·05	·22	·07
Konawaruk Road, 12 miles	,,	3·47	23·10	38·12	20·58	6·98	7·50	,,	·02	·03	·06	·12	trace
,, 14 ,,	,,	6·92	6·30	24·87	42·21	8·90	10·54	,,	·08	·05	·03	·08	·01
,, 14½ ,,	,,	8·12	38·30	21·95	6·39	11·83	12·92	,,	·12	·07	·08	·16	trace
,, 16 ,,	,,	7·87	3·10	13·60	42·45	17·60	14·76	,,	·09	·23	·04	·10	·16
Aruka River—													
Maburima	Hornblende-schist	16·16	9·10	·35	29·16	15·65	35·92	,,	·01	·07	·02	·91	trace
Woopu	,,	6·46	57·30	3·41	11·80	8·46	12·16	,,	·01	·04	·01	·03	trace
Issorora	Epidiorite	10·53	40·60	1·06	16·67	14 58	16·30	·06	·16	·08	·04	·06	·01
Barama River—													
Hyama	Hornblende-schist	11·31	1·60	27·65	20·40	19·13	18·69	·72	·11	·15	·04	·11	·04
6 miles from Towakaima .	,,	4·80	20·30	38·53	22·97	3·16	9·83	·04	·09	·16	·03	·07	trace
Takatu Creek	Chlorite-schist	9·30	nil	49·13	24·65	5·22	10·93	·32	·10	·12	·04	·10	·06
Demerara River—													
Malali	Diabase	5·58	49·60	7·56	20·04	6·08	10·86	nil	·08	·07	·01	·10	trace
Akyma	Porphyrite	8·32		45·71	35·78	3·07	6·53	,,	·12	·17	·18	·01	trace
Christianburg	,,	5·39		40·43	50·21	1·31	2·44	,,	·11	·02	·08	trace	·01

The analyses of the soils were made in the manner usual in analysing them. The soils were digested in hydrochloric acid containing 20 per cent. of real acid at the temperature of boiling water for five working days, and the determinations of the constituents dissolved were made by well-known processes of analysis, a description of which it is not necessary to give here.

Although the analyses are of value as indicating the general characters of the soils on the residual earths in the lateritic areas and as showing in some cases the presence of alumina in a state or states in which it is readily dissolved by hot diluted hydrochloric acid in higher proportions than are usually dissolved from either temperate or tropical soils, it is evident that they do not indicate whether the alumina which is soluble in hydrochloric acid is present in the form of hydrate or as fairly easily decomposable silicates.

As I pointed out in a paper on the Oceanic Rocks of Barbados (Q.J.G.S., vol. xlviii, May, 1892, pp. 190, 191), the action of hydrochloric acid in the silicates present in earths and clays is dependent for its extent on variations in the strength and the temperature of the acid and in the duration of its action. This is true also of other acids. It is not feasible as far as my experience goes to regulate these factors so that only the uncombined or hydrated alumina present in an earth is dissolved without any of the aluminous silicates being attacked and supplying some of their alumina for solution in the acid. Hence it is necessary in the study of the earthy decomposition products of rocks with the view of ascertaining the nature and proportions of their proximate components to analyse them by methods which ensure their complete decomposition, and guided by the indications of microscopical examination of the earths to calculate the proportions of their proximate constituents by means of the figures obtained by the analyses.

Aided to a very great extent by Mr. K. D. Reid, an Assistant Analyst in the Department of Science and Agriculture of British Guiana, I have made in addition to earlier ones a series of more complete analyses by following with some additions and modifications the methods I described in papers dealing with the compositions of the oceanic rocks of Barbados and of certain oceanic oozes (Q.J.G.S., vol. xlviii, pp. 182–3, May, 1892; vol. li, p. 314 et seq., August, 1895).

In the discussions which follow in this paper the probable proximate composition of the samples which have been examined have been calculated on the assumption that the minerals present are in the condition of maximum hydration corresponding to the proportions of water found in the samples, that the potassium, sodium, and calcium oxides[1] found therein are in the form of felspars or of sericite, according to the indications of microscopical and physical examinations; the magnesium oxide has been calculated to talc, its most stable form of hydrated silicate under weathering; the portion of the combined silica not required in these combinations has been calculated to

[1] Calcium oxide is usually found in very small proportions, and in the residual earths is generally present as a constituent of epidote.

kaolinite,[1] whilst the residuary alumina unallotted to them has been assumed to be present as aluminium hydrate, the composition of the hydrate being dependent on the relative available proportions of alumina and of water; and the hydrate so calculated for convenience has been termed bauxite—a possible terminological inexactitude which I trust will be condoned by Mr. Crook.

In samples which showed the presence of an excess of water, after allowing for the various hydrated aluminous and magnesian minerals assumed to be present, the excess of water has been calculated as combined with iron peroxide to form limonite. I have not attempted in cases where the excess of water is insufficient to combine with all the iron oxide, other than that present as ilmenite, to form limonite, to show the iron oxide as one of the ill-defined reputed hydrates of iron, but have regarded it as being in the form of mixtures in various proportions of hæmatite and limonite. The titanium oxide has been shown as present in the form of ilmenite, a mineral very resistant to decomposition under the conditions existent in the Guianas, and constantly found in the residual earths and the ferruginous and aluminous concretionary masses.

The Residual Products of the Weathering of Rocks of the Diabase-Gabbro type.

To ascertain the nature of the residua resulting from the decomposition in situ under tropical conditions of basic igneous rocks, a study has been made of the various components of such decomposition-products at the Agricultural Experiment Station of this Department at Issorora Hill, part of the Aruka range, which is situated about 17 miles from the seashore, in the north-western district of British Guiana, about 130 miles to the north-west of Georgetown, and about 10 miles from the Venezuelan boundary, the Amacura River. This isolated range of low hills, which extends for about 20 miles in a south-westerly direction, consists of epidiorite and of hornblende-schist, the metamorphosed products of a diabase or gabbro, which are covered by a blanket-like coating of red earth with, in its upper layers, numerous blocks of concretionary ironstone, and this covering supplies an excellent example of the material not unfrequently described as laterite by agriculturists, engineers, and mining experts.

Examination in the field shows that the covering consists of a gravelly bright-red earth, similar to that which is termed in Brazil *terra roxa* and in Venezuela *cascajo*, in which is embedded masses of concretionary ironstone, varying greatly in size, in colour, and in texture, but usually being ruddy, scoriaceous, cindery, or slaggy-looking masses, with innumerable small cavities; large angular masses of white quartz, and numerous small pisolitic granules of ironstone. Concretionary ironstone of the kind above described is known in

[1] The statement that kaolinite is never a product of weathering but is always due to deep-seated changes cannot be accepted for the Guianas, where granitic and similar rocks are found converted by surface changes (weathering) into quartziferous kaolins, and the various stages of such conversion can be readily followed in the field in many places.

Surinam as *Kakerlogston*, in French Guiana as *Roche à Ravet*, and is termed in Brazil *Pedra de ferro* and in Venezuela *Moco de hierro.* Samples of the various types of ironstone, of the quartz and of the earth with its ferruginous pisolites, which are present in it to the extent of 45·8 per cent. of its weight, were collected at my direction by the officer in charge of the station, and have been examined by Mr. Reid and myself in the Government Laboratory of British Guiana.

The ultimate composition of the epidiorite at Issorora, of the red earth, of the pisolitic ironstone granules, and of the various types of the concretionary ironstone found there was determined with the results shown in Table III (p. 445).

Aided by microscopical examinations of the material the mineralogical components of the rock and of its decomposition-products have been calculated as shown in the following table:—

Table II.

	Epidiorite.	Red Lateritic Earth. Nos. 1 and 2.	Iron-stone Pisolites.	Concretionary Ironstones.		
				Nos. 1 and 2.	Nos. 3 and 4.	Nos. 5 and 6.
Quartz	1·3	2·5	1·4	·1	·1	·1
Colloid Silica						
Orthoclase	·5	·8	1·5			
Plagioclase	55·1	2·9	·4	1·3	·6	·8
Hornblende and Pyroxene	38·0	nil				
Magnetite	2·8					
Hæmatite		23·7	55·4	18·2	29·0	19·0
Limonite			15·9	74·1	54·0	12·5
Ilmenite	1·7	4·3	3·6	·6	·6	·6
Kaolinite		39·4	3·7	2·4	7·7	24·5
Talc		2·3	·7	1·4	1·7	·8
*Bauxite		24·2	17·1	1·6	6·6	41·7
*Minor constituents	·6		·3	·3		
	100·0	100·1	100·0	100·0	100·3	100·0
*Diaspore		12·0				6·6
Gibbsite		12·2	17·1	1·6	6·6	35·1
*Total Alumina present in Bauxite		18·9	11·2	1·0	3·8	28·6

The foregoing representatives of the class of more or less ferruginous and aluminous deposits which in the Guianas for many years commonly have been termed 'laterite' do not possess, except in the case of the concretionary ironstones, the property laid down by Buchanan as being characteristic of 'laterite'—that of 'setting' or hardening on exposure to the atmosphere. Parts of them agree to some extent with what has been laid down as the modern scientific qualification

TABLE III.—ISSORORA HILL, ARUKA, NORTH-WESTERN DISTRICT.

	Epidiorite.	Red Lateritic Earth.		Pisolitic Ironstone in Nos. 1 and 2 45°/o.	Concretionary Ironstones.					
		No. 1.	No. 2.		Dark brown with yellow patches. No. 1.	Light brown with yellow patches. No. 2.	Light brown, light yellow patches. No. 3.	Brownish yellow with red spots. No. 4.	Dark yellow veined with brick-red. No. 5.	Dark brown with yellow patches and with white streaks. No. 6.
Quartz	1·30	1·59	3·48	1·38	·10	·09	·08	·08	·23	·06
Colloid Silica . . .	—	·10	·10	·18	·16	·14	·18	·03	·03	·38
Combined Silica . .	47·76	25·13	22·60	3·37	2·55	2·69	4·27	5·58	9·56	14·25
Aluminium Oxide .	18·87	31·83	33·37	13·03	2·47	2·55	6·69	7·09	37·10	39·83
Iron Peroxide . .	1·89	25·60	26·73	71·86	82·15	81·59	74·55	76·33	38·39	21·53
Iron Protoxide . .	4·51	—	—	—	—	—	—	—	—	—
Magnesium Oxide .	10·95	·96	·60	·14	·66	·25	·81	·25	·25	·22
Calcium Oxide . .	11·70	·81	·07	·07	·17	·35	·17	·08	·22	·09
Sodium Oxide . .	0·97	·11	·04	nil	traces	traces	traces	trace	trace	trace
Potassium Oxide . .	0·06	·07	·25	·28	traces	traces	traces	trace	trace	trace
Water	0·43	12·52	10·83	8·28	11·76	11·50	12·45	10·01	14·10	22·64
Litanium Oxide . .	0·88	1·70	2·35	1·87	·31	·23	·19	·27	·49	·17
Phosphoric anhydride	trace	trace	trace	nil	nil	trace	trace	trace	trace	trace
Manganese Oxide .	0·34	·10	nil	nil	nil	nil	·15	nil	nil	1·08
	99·66	100·52	100·42	100·46	100·33	99·39	99·54	99·72	100·37	100·25

for a rock to be termed 'laterite'—the fact that they are "essentially characterized by the presence of free hydrate of alumina"; but the question remains: If it is allowable to term 'laterite' the earth and its pisolites which contain, in round figures, 24 per cent. of 'bauxite', and the concretionary masses which contain 42 per cent. of it, what are their accompanying masses which contain only from 2 to 7 per cent. of bauxite to be called? Are we to find another name for these masses whilst they are in situ, or may we not reasonably include them with the other components of the residuary products of the rocks as a whole under a wide-meaning term 'laterite'?

Another type of the deposits formed by the decomposition of diabase and of hornblende-schist in situ is illustrated by samples from Tumatumari, Potaro River; the Penal Settlement at Mazaruni, Mazaruni River; and the Omai Falls at the Omai Gold Mine, Essequibo River. Their compositions and those of the rocks from which they are derived are as follows:—

Table IV.

	Tumatumari.		Omai Falls.		Mazaruni.	
	Diabase.	Laterite.	Diabase.	Laterite.	Hornblende Schist.	Laterite.
Quartz	3·20	47·35	6·50	38·66	7·60	32·51
Colloid Silica		·06		·17		·05
Combined Silica . . .	47·99	3·30	46·75	7·90	44·10	14·93
Aluminium Oxide . . .	15·80	26·33	17·16	18·41	15·94	34·14
Iron Peroxide	3·08	10·67	4·27	22·35	3·84	7·64
Iron Protoxide	11·20	8·26	8·26		10·56	
Magnesium Oxide . . .	5·63	·21	6·10	·12	5·54	·11
Calcium Oxide	9·58	·23	7·46	·11	9·60	·01
Sodium Oxide	2·09	·14	2·50	·15	1·87	·53
Potassium Oxide . . .	0·60	·21	0·69	·47	·08	·48
Water	0·30	11·28	0·32	10·97	·30	9·00
Titanium Oxide	0·40	·67	0·32	·50	·30	·90
Phosphoric Anhydride . .	0·008	trace	trace	trace	·01	·02
Manganese Oxide . . .	trace	nil	0·12	nil	trace	nil
	99·878	108·71	100·45	99·81	99·74	100·32

The mineralogical components of the rocks and of their resultant laterites have been calculated as shown in Table V (p. 447).

These residual earths are as characteristic of many of the residuary products of basic rocks as those at Issorora are of others. But in them, in place of the silica segregating out into masses of quartz, and only occurring to a very limited extent as fine gravel or sand, the quartz occurs in quantity as very fine angular gravel and sharply angular sand of very varying degrees of division, but mostly of exceeding fineness, dispersed through the mass, by far the greater part of the quartz being of secondary origin. In them, as a rule, the concretionary ironstones are less in evidence than they are at Issorora, but in time the weathered surfaces of the earths become covered by quartz-sand and gravel, with in places pisolitic granules of concretionary ironstone, whilst they contain here and there in their upper parts masses of concretionary ironstone, some of which attain weights of over a ton, and which masses, as are some of those at Issorora, are in parts more or less bauxitic.

TABLE V.

	Tumatumari.		Omai Falls.		Mazaruni.	
	Diabase.	Laterite.	Diabase.	Laterite.	Hornblende Schist.	Laterite.
Quartz	3·2	47·3	6·5	38·7	7·6	32·5
Colloid Silica		·1		·2		
Orthoclase	3·3	1·3	3·9	2·8	·5	2·8
Plagioclase	49·8	2·3	40·6	1·8	30·9	4·5
Hornblende and Pyroxene	38·0		42·2		53·9	
Magnetite	4·4		6·3		5·6	
Hæmatite		10·0		7·2		6·7
Limonite				17·2		
Ilmenite	0·8	1·3	0·6	·9	0·6	1·7
Kaolinite		1·3		10·1		20·1
Talc		·7		·4		·3
*Bauxite		36·0		20·5		31·5
*Minor constituents	0·5			·2	0·9	
	100·0	100·3	100·1	100·0	100·0	100·1
*Diaspore		5·2				24·0
Gibbsite		30·8		20·5		7·5
*Total Alumina present in Bauxite		25·0		13·4		25·3

As a rule they do not show the hardening properties of Buchanan's laterite, but if we are to take the presence of free alumina in the form of hydrate as the definitive test of whether a mass has a right to be termed 'lateritic', they are clearly lateritic earths.

The Residual Earths from Sericite and Chlorite Schists.—As examples of a type of residuary earths which exhibit to a considerable extent the setting properties from which Buchanan derived the term laterite, may be adduced certain ferruginous earths which contain sericitic micas in such quantities that the principal aluminous components are sericite, kaolinite, and bauxite, instead of being kaolinite and bauxite, with a little residuary felspar, as are those of the types already considered. The best examples of these I have seen occur at the Omai Gold Mines, Essequibo River, where a ditch between two and three miles in length and several tunnels were cut through them for the purpose of conveying water for the hydraulic workings. Their mass was quite soft when first dug into, but gradually became indurated on exposure to the atmosphere to the consistency of soft rock, so that the sides of the ditch and the sides and roofs of the tunnels became firm enough to allow of the rapid passage of water along and through them without any artificial supports being required either for the sides of the trench or the roofs of the tunnels.

The hardening was accompanied by a gradual darkening in the colour of the rock, this indicating changes in the states of hydration of the oxides of iron present in them.

At Omai these earths are largely the residua from the decomposition of sericitic and of chloritic schists, which latter frequently contain sericite in considerable proportions.

At Omai the rocks are completely decomposed to depths of 100 to 150 feet, and owing to this and to the intricate nature of the complex of sericitic, hornblendic, and chloritic schists, epidiorites and porphyroids, traversed by veins of sericitized aplite and felspar-porphyrite and by sills of diabase, it is not possible to ascertain which rock or rocks by decomposition gave rise to the sericitic earths. Hence I have not analysed the specimens of sericitic and other schists of which the cores of the diamond-drill borings obtained at Omai largely consist, and therefore it is not feasible to contrast the compositions of the residual earths with those of the rocks from which they have been derived.

The ultimate compositions of representative samples of the sericitic earths are as follows:—

Table VI.

	Brownish red.	Yellowish brown.	Yellowish brown.	Purplish red.
Quartz	11·17	31·44	37·28	7·05
Colloid Silica	·30	·14	·23	·08
Combined Silica	24·04	19·58	16·54	14·53
Aluminium Oxide	23·94	27·21	24·98	21·34
Iron Peroxide	24·65	8·78	7·57	39·03
Magnesium Oxide	·30	·23	·21	·08
Calcium Oxide	·10	·06	·06	·05
Sodium Oxide	·10	trace	trace	·25
Potassium Oxide	1·27	1·55	1·85	2·58
Water	11·70	9·79	11·27	13·22
Litanium Oxide	2·31	·65	·70	2·35
Phosphoric Anhydride	trace	trace	nil	nil
Manganese Oxide	nil	nil	nil	trace
	99·88	99·43	100·69	100·56

The average proximate mineralogical composition of the earths when calculated out in the manner already described is as follows:—

Table VII.

Quartz	21·7
Colloid Silica	·2
Sericite	16·9
Hæmatite	2·6
Limonite	18·6
Ilmenite	2·9
Kaolinite	23·0
Talc	·7
*†Bauxite	13·5
	100·1
*Gibbsite	13·5
†Total Alumina present in the form of Bauxite	8·9

The surfaces of the residual earths are covered with ironstone, gravel, and conglomerates, whilst at depths of some feet from the surface layers of angular quartz gravel occur. In many places the earths are seen to be traversed by numerous thin veins of quartz, some of which are normal to the original schists, whilst others are clearly of secondary origin, their silica having been derived from the decomposition of the felspar and ferruginous minerals of the rocks.

Layers of ironstone conglomerates and masses of concretionary ironstone similar to those at Issorora everywhere cover to a depth of about 2½ feet the surface of the hills at Omai. Like those at Issorora the concretionary ironstones are in places more or less aluminous.

Laterite from Felsite or Porphyrite, Demerara River.—At Christianburg, on the Demerara River, about 58 miles south of Georgetown, where the Government has a Para rubber experiment station, the surface of the low hills is a sandy soil which rests on beds of cream-coloured, reddish-grey, or red highly aluminous laterite or 'bauxite'. The bauxite is also exposed in shallows in the bed of the river between Christianburg and Wismar, and it gives rise to a low hill at Akyma, some 11 miles south of Christianburg. Microscopic examinations of the bauxite show that it has been derived from a felsite, a porphyrite, or possibly a tuff. Felsite and porphyrite are exposed in the Kumaru Creek close to Akyma Hill, where they are intrusive in gneiss. At Christianburg the bauxite apparently is underlain by a pale buff-coloured arenaceous clay.

In this district generally as well as at the Christianburg and the Akyma Hills the surface soil over the lateritic decomposition-products is a sand varying from white, glistening, almost pure quartz sand, containing over 96 per cent. of quartz, to a brownish highly arenaceous soil, with from 40 to 50 per cent. of quartz, the former variety containing less than ½ per cent., the latter from 2 to 6 per cent. of free alumina, whilst below it the subsoil contains less quartz—from 20 to 45 per cent.—and somewhat higher proportions of free alumina, these ranging from 5 to about 7 per cent.

The soil is underlain by a somewhat thick deposit, the depth of which has not been determined, of masses of cream-coloured bauxite, which in parts are more or less stained with iron, or where reddish grey to red in colour are more or less ochreous or limonitic. Some masses resemble in colour and general characters the concretionary ironstones described under numbers 5 and 6 of the Issorora District. Specimens of this kind were obtained from a shoal in the Demerara River near Wismar, about half a mile south of Christianburg.

The compositions of the samples of the sands, of the bauxites, of the underlying clay, and of the hornblende-felspar-porphyrite from which they were presumably derived are as follows :—

Table VIII.

	Hornblende Felspar Porphyrite.	Christianburg.			Bauxite or Laterite.	
		Sand.	Bauxite or Laterite.	Clay.	Akyma.	Wismar.
Quartz	34·10	96·80	·42	38·79	·67	4·74
Colloid Silica			·14	·53	·12	·62
Combined Silica	36·86	1·13	2·29	25·50	1·92	3·58
Aluminium Oxide	16·64	·97	67·28	21·16	64·86	45·14
Iron Peroxide	0·22	·64	1·53	3·74	·85	23·03
Iron Protoxide	1·48					
Magnesium Oxide	1·29	·02	·07	·49	·31	·31
Calcium Oxide	3·46	·08	·02	·08	·03	trace
Sodium Oxide	4·39	·08	nil	·48	nil	nil
Potassium Oxide	0·24	·01	·08	2·00	·15	·15
Water	0·68	·25	27·46	6·67	30·47	21·68
Carbonic Anhydride	0·42		trace		trace	nil
Litanium Oxide	0·38	trace	1·07	·67	·75	1·12
Phosphoric Anhydride	0·006	·006	trace	trace	trace	trace
Manganese Oxide	0·10	trace		nil	nil	nil
	100·266	99·986	100·36	100·11	100·13	100·37

The proximate mineralogical compositions of the porphyrite, the bauxitic masses, and of the clay underlying the latter are as shown in Table IX (p. 451).

The bauxitic masses fully correspond to the typical laterites in the restricted sense laid down for the late Dr. Buchanan by Mr. Crook. They are when first dug fairly soft, and easily trimmed into shape for building purposes by a trowel or heavy knife. They have been used for building purposes in the foundations and retaining walls of the Government Saw Mill at Christianburg, and also in walls at Akyma. After exposure to the atmosphere the masses have quickly set and attained a hardness corresponding in the lighter-coloured or more purely bauxitic parts to somewhat less than three in Mohs' scale of hardness, and in the ferruginous parts to somewhat over that degree. The marked hardening is to a considerable extent confined to the exposed surfaces.

I have examined microscopically thin sections of the bauxite masses from Christianburg. Their general structure is that of a metamorphosed felspar-porphyrite or tuff in which the original minerals with the exception of the ilmenite have been impregnated with or replaced by hydrates of alumina in an amorphous concretionary form. The amorphous matter is mingled here and there with very minute particles of quartz, and it is traversed by very thin veins of chalcedonic silica, some of which appears to be tridymite. The ilmenite is present in the form of widely, though sparsely, scattered exceedingly minute

TABLE IX.

	Hornblende Felspar Porphyrite.	Christianburg.			Bauxite or Laterite.	
		Sand.	Bauxite or Laterite.	Clay.	Akyma.	Wismar.
Quartz	34·1	96·8	·4	38·8	·7	4·7
Colloid Silica			·1	·5	·1	·6
Orthoclase	1·4	trace[1]	·5	11·8	·9	·9
Plagioclase	51·0	1·1	·1	4·4		
Hornblende and Pyroxene	12·0					
Magnetite						
Hæmatite		·6	·5	3·1	·1	21·9
Ilmenite	·8		2·1	1·3	1·4	2·1
Kaolinite		1·1	3·3	29·8	1·5	4·3
Talc			·2	1·6	1·0	1·0
Calcite	·9		trace		trace	
*Bauxite		·4	92·6	8·9	94·4	64·6
*Minor constituents			·2			
	100·2	100·0	100·0	100·2	100·1	100·1
*Diaspore			26·1			
Gibbsite		·4	66·5	2·0	12·1	6·6
*Total Alumina present in		·3	65·7	6·9	82·3	58·0
Bauxite				5·3	64·1	43·0

[1] Muscovite.

grains, none of it, however, being in the siliceous veins. The thin sections examined were cut from some of the more siliceous parts of the bauxite. The microscopical structure of the bauxite closely resembles that of the "Oolithartige Bauxit" of Surinam, described by Du Bois as follows on pp. 35–9 of his monograph "Beitrag zur Kenntnis der Surinamischen Laterit" (*Tschermak's Mineralogische und Petrographische Mitteilungen*, Band xxii, Heft i, 1903):—

"Only in a very thin section of the fresh, oolite-like substance could the separation of secondary silica be demonstrated with certainty. The ground-mass of the nodules and the cement is composed of feebly translucent yellow substance apparently amorphous. Some of the concentric parts—generally the outermost—are strongly impregnated with microscopic granules of chalcedony. The intermediate mass or the cementing substance of the nodules is remarkably rich in secondary silicic secretions. Septarian-like veins which traverse obliquely the nodules also show the partial silicification."

The earth underlying the bauxite at Christianburg was microscopically examined, and was found to contain a considerable proportion of orthoclase felspar in a very finely divided angular condition. Some minute angular grains showing the striæ of plagioclase were also detected. It seems probable from this and from its chemical composition that the arenaceous clay was derived from a different rock to that which gave rise to the bauxite, possibly from the granitite-gneiss which is the principal component of the fundamental complex of the Demerara–Essequibo district.

(*To be continued.*)

IV.—On the Superficial Deposits at the Foot of the Cheviot Hills between Wooler and Glanton.

By R. G. A. Bullerwell, M.Sc.

(PLATE XXXV.)

Introduction.—Lying at the foot of the Cheviot Hills are deposits of sand and gravel, which, between Wooler on the north and Glanton on the south, cover a considerable area, occupying the greater part of the lower valleys of the Breamish and other tributary streams of the Till. They form mounds and ridges running in different directions, often dividing and reuniting in a very irregular manner. They are indicated, along with deposits at greater altitudes, on the Drift Edition of the Map of the Geological Survey of England (Sheets 109 N.W. and 110 S.W.) as "sands and gravels of Glacial age". It is for the purpose of describing these accumulations and in some measure elucidating their source and mode of deposition that this paper is written.

Literature.—Concerning these sands and gravels very little has previously been published. Professor G. A. Lebour, M.A., M.Sc., F.G.S.,[1] doubtfully places them along with other deposits in Northumberland and Durham, evidently more recent than the Boulder-clay, under the head of "Upper Drift Sands and Gravels".

Writing in 1872 on "Langleyford Vale and the Cheviots", Dr. J. Hardy[2] noted the water-worn character of the gravels. "The Wooler Water," he says, "works its uncertain way among congeries of ancient gravels and rolled masses, often disturbing and ploughing them up, but adding nothing to the spoils brought thither by earlier and more intensified agencies that scooped the channel for the present diminished stream."

Earlier still, in 1865, Mr. Tate, F.G.S.,[3] in his paper "Records of Glaciated Rocks in the Eastern Borders", pointed out the well-rounded gravels which had previously been referred to as Glacial Moraines by Dr. Buckland.

[1] *Handbook of the Geology of Northumberland and Durham.*
[2] Proceedings of Berwickshire Naturalists' Club, 1872.
[3] Ibid., 1865.

Valuable information as to the condition of the Cheviots during the Glacial Period is to be obtained from Mr. C. T. Clough's memoir[1] "On the Geology of the Cheviot Hills", and from the paper by Professor P. F. Kendall, F.G.S., and Mr. H. B. Maufe, B.A., F.G.S.,[2] "On the Evidence of Glacier-dammed Lakes in the Cheviot Hills."

The Glacial deposits of the adjacent country between Wooler and Coldstream are described in the memoir by Mr. W. Gunn, F.G.S., and Mr. C. T. Clough, M.A., F.G.S.[3]

Physical Structure of the District.—The range of the Cheviots culminates in the north-east in the granite hills of Cheviot, Hedgehope, etc. This granite area is surrounded by tuffs and porphyrites contemporaneous with the Old Red Sandstone. Between Wooler and the Breamish the porphyrites present a steep but curved slope facing E.N.E. and east, and enclose between South Middleton and Roddam red marls, sands, and thick beds of conglomerate.[4] The range is intersected by several valleys, the present pigmy streams in many cases being grotesquely out of proportion to the amount of denudation, and presenting a striking contrast to the more powerful subaerial agents of denudation originally employed in their excavation.

Resting unconformably upon these rocks are those of the Carboniferous Series, consisting chiefly of sandstones, grits, and impure limestones. They extend outward from the Cheviot area, with a generally gentle slope towards the east. The Fell Sandstones of this series form ridges and crags at considerable elevation on the eastern side of the Till, their rugged and steep escarpments boldly contrasting with the rounded form of the porphyrites rising above the valley on the opposite side. All the streams included in the area are tributary to the Till, itself tributary to the Tweed, and which in its upper course is known as the Breamish, taking its rise in Cheviot, flowing first south-east, then east, and near Hedgeley sweeping round in a northerly direction.

Glaciation of the Cheviots.—While the higher summits appear never to have been overridden by foreign ice, but to have acted as independent centres of glaciation, two foreign streams advanced upon the Cheviots, one from the south-west and the other from the north, but whether they were contemporaneous or successive is not readily determined. Both the eastern and southern margins have evidently been overridden by foreign ice up to a height of 1000 feet, as indicated by striæ and the presence of transported boulders.

Mr. Clough has described the foreign rocks occurring in the drift near Skirlnaked and pointed out a track of foreign boulders crossing the porphyrite hills from the north to this locality. On the other hand, however, the striæ and boulders occurring on the south-east margin of the Cheviots indicate transport from the south-west.

On Carboniferous rocks west of Black Hill, Ford Moss, Messrs. Gunn and Clough found striæ indicating a direction from east to west.

[1] Memoirs of the Geological Survey of England and Wales.
[2] Transactions of Edinburgh Geological Society, vol. viii, 1902.
[3] Memoirs of the Geological Survey of the United Kingdom.
[4] [Basement Beds of the Carboniferous.—Ed.]

The northerly flow along the Cheviots was evidently produced by a deflection of this easterly or north-easterly flow from the Tweed Valley. On the sandstone of Bewick Hill are striations pointing direct north and south.

Description of Sands and Gravels.—Sands and gravels cover the tract between the high land above Wooler and Glanton Pike, and are bounded on the west by the Old Red Sandstone conglomerates or Basement Beds of the Carboniferous Series. The eastern limit is more difficult to define, but gravel and sand deposits abut against the Carboniferous rocks of Bewick Hill, and may extend into the Eglingham Valley. They form hummocks and meandering ridges continually dividing and reuniting in a most confusing and irregular manner, but with the long axes of the ridges most frequently running north and south. In the lower valley of the Breamish the sands and gravels are more diffused, but this may be due to subsequent re-arrangement by later agencies. The mounds and ridges may be well seen between Wooperton Station and New Bewick where the road crosses them, also between East Lilburn and the same station where the view looking towards Bewick Hill embraces a large tract covered with kame-formed ridges of gravel. The undulating formation is most pronounced in the areas adjacent to the river valleys where the deposits are thickest. In several cases the sands are cut through by streams and present steep sloping faces fronting the valleys. Such banks may be seen in Coldgate Water, Roddam Dean, near East Lilburn, and below Hedgeley Low Farm (Fig. 1, Pl. XXXV). The sand is composed of coarse irregular grains, and contains occasional well-rounded pebbles. The deposits generally follow the 300 feet contour-line.

The section below Hedgeley is almost entirely of sand, but contains limestone and porphyritic pebbles. It rises about 40 feet above the level of the alluvial plain. The banks may be followed for about a quarter of a mile and end in a spit which slopes gently eastward. The surface is a plateau, broken here and there into hummocks and hollows.

Many of the hummocks might be described as kame-formed and reach the contours of 300 and 400 and in a few cases to the 500 feet line. This is the greatest elevation to which it is necessary to refer for the purposes of the present paper. Whenever the 300 feet contour is the limit and any opportunity whatever given for examining the contained pebbles these are seen to be well rounded.

Generally speaking, coarse gravels are to be seen on the western boundary where the deposits abut against the Cheviots, passing into finer gravel, followed by sand, with sparsely occurring pebbles as they are traced eastward. The gravel is usually composed of material derived from rocks in the immediate neighbourhood (porphyrite, etc.), but a considerable quantity of it is evidently derived from foreign sources.

Much of the district covered with gravel is tilled, only a small area, apart from the low marshy soil of Hedgeley, etc., being devoted to pasturage. Where cultivated the soil is invariably heavily charged with pebbles of varying texture, and in early spring after heavy rains the hummocks resemble nothing so much as mere mounds of loose well-rounded stones. Notwithstanding the thin gravelly soil, however, the farmers informed me that good crops are the rule.

Sections.—On the left bank of Wooler Water and following the 300 feet contour-line, sands and gravels are exposed and may be examined between Earle Mill and Coldgate Mill. A few yards south of the former the section consists of gravel, sand, and clay, irregularly bedded. The gravel is water-worn and rounded. False bedding which probably represents a rapid deposition of sand is shown by a banded appearance due to alternate layers of material of darker and lighter colour. Gravel and sand alternate irregularly with each other, and may be seen when the bedding is not obliterated by the falling down of the sand and clay from the upper portion of the section. South of this the entire section is sand with few pebbles. The bedding is very distinct.

At a point almost opposite Haugh Head and a few yards below the bridge a section showing coarse and fine gravel with sand is exposed. The bedding is clear, but layers of the same texture rarely extend for any great distance or continue across the entire length of the section, which is about 80 feet. The included rocks, which are without exception well rounded and water-worn, are of yellow sandstone, Carboniferous Limestone, and porphyrite, the largest being of arenaceous rock and measuring up to 15 feet in girth, together with smaller fragments of quartz, jasper, lydian stone, slate, and Silurian greywacke. Some of the gravel is cemented together, the cementing material being calcium carbonate. The coarse gravel frequently contains washings of fine gravel and sand. The section, which rises to about 30 feet above the river-level (see Fig. 2, Pl. XXXV), consists of the following:—

(*a*) 2½ feet, sand.
(*b*) 2½ feet, fine gravel and sand.
(*c*) 5 feet, coarse gravel.
(*d*) 2½ feet, fine gravel with a few large boulders.
(*e*) 5 feet, coarse gravel, continuous with (*g*).
(*f*) 2½ feet, fine gravel, bedded.
(*g*) About 10 feet, coarse gravel, with bed of fine gravel and sand about 2 feet from base. There is much limestone and yellow sandstone and several bands of sand and dirty gravel cemented together. Some of the cementing matter is oxide of iron, which gives a rusty appearance to the lower portion.

From this point up to Coldgate Mill are banks of coarse gravel and sand usually grass-grown and offering little opportunity for examination. Near Coldgate Mill the deposits abut against porphyrites, just below the 400 feet contour-line.

These sands and gravels form a plateau rising here and there into hummocks and ridges, ascending gradually to the 400 feet contour-line, where they abut against the porphyritic masses of Earle Hill, Whinnie Hill, etc. These hills are all divided by valleys, sometimes dry, below the 500 feet contour-line.

South Middleton to Lilburn. — Just below South Middleton is a dry valley through porphyrite, and like the majority of these valleys running north and south. Below this is moraine matter, which spreads out eastward, gradually assuming the characteristics of the water-worn gravels. Towards Lilburn is a long stretch of rolling country, over the surface of which rounded pebbles lie scattered.

The railway cuts one of the hummocks above the 300 feet contour-line. The section about 25 feet above the railway level is obscured by the falling gravel and sand, but the pebbles are all well rounded and consist of quartz, porphyrite, sandstone, limestone, etc. A few of the fragments retain evidence of glacial striation.

From Kingston Dean to Roddam Dean and between the 400 and the 500 feet contour-lines gravels abut against a cliff of Old Red Sandstone conglomerate. At the entrance to Roddam Dean the following section is exposed for a length of about 85 feet:—

(*a*) 2 feet, fine gravel.
(*b*) 22 feet, sand.
(*c*) 8 feet, coarse gravel, with occasional washings of reddish-brown sand. The gravel is composed chiefly of arenaceous rock, carbonaceous matter, quartz, ironstone, porphyrite, and Carboniferous Limestone.

The largest boulder in this section measured 2 feet in girth. Some of the gravel is cemented together, the cementing medium being iron oxide. Fossils of Carboniferous Limestone and glacially striated boulders occur.

South of Roddam Dean, and between the Roddam Dean conglomerates on the north and porphyrites on the south, is a large tract covered with sand and gravel, forming hummocks and ridges, with kettle-holes. The highest reach to the 400 feet contour-line. One of them, just below Wooperton Dean, evidently another ancient valley, is a kame-like ridge, about 800 feet in length, formed of coarse gravel and sand, the former varying from small pebbles no bigger than a pea to masses 27 inches in girth.

The ridge rises some 45 feet above its base. The materials are of sandstone, porphyrite, granite (Cheviot), tuff, and conglomerate from the north of Cheviot, and are rounded or subangular. The mass resembles that occurring below South Middleton. A pit a few yards away contains sand with very few pebbles.

Between Wooperton Dean and Brandon Dean is another ridge resembling the one just described. The two tiny streams occupy a valley once continuous, uniting the Breamish and Roddam Burn Valleys. Here, too, the debris passes downwards, and the sands and gravels are spread out over the 300 feet contour, where, however, they are all undoubtedly water-worn.

Recent Deposits.—A large area is covered with the alluvium of the Till and its tributary streams. This consists of loam, sand, and gravel. Most of the streams are still liable to flood, but evidently at some period, probably before the ice had finally disappeared from the greatest elevations, the dimensions of the swollen streams must have been prodigious, consequently much more of the valleys were submerged than now. The expansion of the alluvial deposits between Hedgeley and Wooperton may be the site of an old lake. The Randy Burn has an erratic course through a yellow and sometimes whitish clay, resembling that seen below the peat in other lake-basins, and covered with gravel and peaty soil. Another large alluvial plain exists south of the Lilburn near Ilderton Station. Old alluvial terraces may be seen at Brandon and Branton.

Occasionally amongst the sands and gravels are depressions, the sites of former small lakes, now containing peat lying upon a yellow or whitish clay. In each case streams run through the hollows, and by diverting the courses of these much former bog land has been reclaimed and is now under cultivation.

Near Wooperton the Roddam Burn cuts through a section in which a bed of peat about 2 feet thick rests upon a yellowish-white clay, and is covered by a thick deposit of fine sand. The same section is continued on the other side of the railway, and from the form of the depression the lake must have been at least three-quarters of a mile in length. The depression is entirely surrounded by kame-like ridges of sand and gravel rising to the 300 feet contour-line.

At Lilburn is a large depression, surrounded by sands and gravels, containing peat in its lowest part, and surrounded by a tract of peaty soil. It is drained by a small stream running right through the peat and across the flat lake-like basin, where its channel has been diverted. A smaller lake, probably connected with this one, lies to the east, near Lilburn Grange.

North of Glanton Pike is a cup-shaped hollow representing another ancient lake-basin. It is surrounded by sands and gravels at the foot of Glanton Pike and a porphyritic offshoot of the Cheviots. Within this is a considerable thickness of peat surrounded by a tract of peaty soil. This basin is drained by the Powburn.

South of the Lilburn and just below Lilburn South Steads is another of these peat-covered tracts. This partakes more of the nature of a bog than a lake, and may have been flooded by overflow water from the Lilburn through a narrow channel which connects it with that stream.

At the head of Kingston Dean below the village of Ilderton two small streams unite and enclose near their junction a triangular-shaped area of peat. The valley, a deep trench through Old Red Sandstone conglomerate, is narrow, and the lake thus formed must have been of very limited dimensions.

Another lake-basin is above North Middleton, and a smaller deposit of peat, Cresswell Bog, opposite Haugh Head, Wooler, in which skeletons of the red deer were found in 1830, represents an overflow basin of the Wooler Water.

Conclusions.—The sections show that the sands and gravels were deposited under water, and the false and irregular bedding seems to indicate rapid deposition. The material, though to a large extent derived from the immediate neighbourhood, includes many rocks that are foreign. The source of supply of this material is readily found when we recognize the source of the drift on the flanks of the Cheviots and the moraine matter in the dry valleys with which these lower sands and gravels are connected. The debris is derived partly from local rocks and partly from foreign erratics left by ice-streams which overran the Cheviots from the north and south-west. The rivers together with water flowing through the present dry valleys fed from the glaciers and glacial lakes at higher altitudes, carried with them the moraine matter, rolling and rounding the rock fragments in their torrents, yet not quite obliterating all evidences of their glacial origin. These streams flowing into the same valley at the foot of the hills must have contained a tremendous volume of water, which being confined by the Carboniferous ranges in the east and probably dammed by ice on the north would fill the channel to a considerable depth. The 500 feet contour-line was well above the line of principal lake-deposition, and probably the 400 feet line or a line between this and 300 feet limited the margin of the lake or series of lakes. The deposits at the higher elevations, while continuous with those confined to the 300 feet contour limit, are undoubtedly composed of material less water-worn. The coarse gravels in the sections near Wooler and Roddam were the littoral deposits, while the finer material and sands of Hedgeley were carried into the quiet and deeper portion of the lake.

The alluvial tracts of the Breamish and other streams, the peat and marl-like deposits of the recent lake-basins were formed after the supply of water to the mountain torrents had diminished but was still very much in excess of their present supply.

EXPLANATION OF PLATE XXXV.

FIG. 1. The Breamish Valley below Low Hedgeley. In the foreground, rising above the alluvial plain, are deposits of sand. The Carboniferous ridges are seen in the distance.

FIG. 2. Section of sand and gravel exposed by Wooler Water near Haugh Head, Wooler.

V.—THE GEOLOGY OF THE TITTERSTONE CLEE HILLS.[1]

By E. E. L. DIXON, B.Sc., A.R.C.S., F.G.S.

THE following is a preliminary account of the rocks overlying the Lower Old Red Sandstone of the Titterstone Clee Hills, Shrops.

Sedimentary Series . . .	4. Coal-Measures.
	3. Millstone Grit (so-called).
	2. Carboniferous Limestone Series.
	1. Upper Old Red Sandstone.
Intrusive rocks . . .	Dolerite.

1. The Upper Old Red Sandstone, consisting largely of sandy and pebbly beds, is fixed in age by its fish-fauna, which has long been known. Its junction with the underlying Lower Old Red marls is perfectly sharp, and probably marks an unconformity. Upwards, however, the group passes into—

2. The Carboniferous Limestone Series. The correlation of the local development with the Avonian of other districts has been sketched by Dr. Vaughan,[2] whose chief conclusion, that the highest recognizable horizon is little, if at all, higher than the upper part of the Zaphrentis Zone, holds good throughout the outcrops. That part of the series which overlies this horizon is so thin that it is difficult to believe that the top is much younger, even after making allowance for the fact that it consists of such shallow-water deposits that its rate of deposition must have been conditioned by the rate of subsidence of the sea-bottom. This conclusion as to age is supported by the age and relations to the local 'Millstone Grit' of the top of the Carboniferous Limestone Series in the Forest of Dean and the Bristol area (op. cit.).

[1] Abstract of paper read at the British Association, Sheffield, September, 1910.
[2] Quart. Journ. Geol. Soc., vol. lxi, pp. 252–4, 1905.

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FIG. 1. The Breamish Valley below Low Hedgeley.
,, 2. Section exposed by Wooler Water near Haugh Head, Wooler.

3. The 'Millstone Grit', which consists largely of sandstones and conglomerates, is undoubtedly conformable with the Carboniferous Limestone Series, and, as regards its base, is probably, from what has just been said, of Syringothyris age, and therefore much older than the Millstone Grit proper. Unfortunately its marine fossils, found at but one horizon, are of no zonal value, but its plants, from various levels, connect it, according to Dr. Kidston, with Lower Carboniferous rocks, not with the Millstone Grit proper. The conclusion as to the age of the lower part may therefore extend to the whole, and it is suggested that a non-committal place-name be applied to this formation instead of 'Millstone Grit'.

4. The Coal-measures include 'sweet', i.e. non-sulphurous, coals at several horizons from the base upward, and have yielded, besides a fairly rich flora, a small marine fauna at one or two horizons. The most important point, however, is the fact that they are not conformable with the 'Millstone Grit'. Their relationship has been revealed in a quarry, where their basal bed, a pebbly sandstone, rests at a low inclination and with marked discordance on evenly-dipping beds of Grit; and it affords the only satisfactory explanation of a transgression of the Measures across the outcrops of the Grits, which is brought out by 6 inch mapping.

As the 'Millstone Grit' is in part much older than the rocks of that name which underlie Coal-measures elsewhere, it becomes of interest to inquire whether the break between it and the Coal-measures on Clee Hill corresponds merely to the period of the Millstone Grit proper, or whether it includes some part of Coal-measure time also. That is, what is the age of the base of the Coal-measures on Clee Hill?

A feature of these measures is the presence in them of red clays and green sandstones of 'espley' type at intervals from a few feet above the base upward. According to Dr. Walcot Gibson rocks of these characters are not known in Coal-measures of other parts of England and Wales from any horizon lower than the Etruria Marls or a short distance below. Stratigraphical evidence also suggests that the Coal-measures of Clee Hill commence at this level. For there is no doubt, as has been pointed out by Mr. Daniel Jones, but that the Clee Hill measures are of the same horizon as the 'sweet coal series' of the adjacent Forest of Wyre Coal-field. There, in the Kinlet district, the junction of this series with the overlying sandstones which yield the 'sulphur coals' was found, in the course of an extension of the work to that neighbourhood, to be a conformable one; and therefore, as the sandstones have been recognized by Dr. Gibson and Mr. T. C. Cantrill as representing the Newcastle-under-Lyme Series, we may conclude that the 'sweet coal series' which, like the Clee Hill measures, include some red clays and 'espley'-like sandstones, corresponds to part of the Etruria Marls. It may be added that the most recent Coal-measures on Clee Hill are sandstones resembling the Newcastle Series of the Forest of Wyre, but too thin (they form an outlier of a few acres extent) and poorly exposed to yield further evidence of their age and relationships.

Against the conclusion that the Clee Hill measures commence with a representative of the Etruria Marls it may be urged that the latter in their typical development[1] yield neither coal-seams nor the flora and fauna which have been obtained on Clee Hill. Similar coals, however, occur elsewhere in England and Wales at intervals up to much higher horizons, though not in association with the typical Etruria Marl rock-facies. The objection based on the flora is of greater weight, for Dr. Kidston finds that the plants are Middle Coal-measure forms, and therefore suggestive of a horizon lower than the Etruria Marls. But it may be remarked that the flora of the Blackband Group immediately below the Etruria Marls—the latter yield but rare plants—include no forms which do not occur in the Middle Coal-measures below.[2] The fauna of the marine bands is unfortunately of no horizonal value, though it includes a *Productus* which Dr. Vaughan finds closely resembles a form (*P.* aff. *scabriculus*, Mart.) abundant in the Avon section and elsewhere at the top of the Dibunophyllum Zone.

Finally, a consideration of the thicknesses and characters of the sedimentary series and of the outcrops of dolerite shows that earth-movements along a N.E.–S.W. line have made themselves felt during—

1. Upper Old Red Sandstone and Lower Carboniferous times.
2. Some period between Lower Carboniferous and Coal-measure times. (The latter movement has resulted in the unconformity between the 'Millstone Grit' and the Coal-measures.)

And further that the dolerite came up through several passages, some of which form a linear series having approximately this trend also.

VI.—The Origin of the British Trias.[3]

By A. R. Horwood,
Leicester Museum.

As a result of an investigation covering the Midland area, and especially from a study of the Upper Keuper of Leicestershire, the author, who has been aided in this research by a grant from the Government Grant Committee of the Royal Society, has arrived at the conclusion that, in so far as Great Britain is concerned, the Trias was laid down under delta conditions, during which, as in the Nile area to-day, æolian action took place, but was not responsible for deposition except locally on a small scale, and following the prevalent wind course.

The premises upon which this view is based are as follows:—

1. There is a continuity of area of deposition during the Upper Carboniferous, Permian, and Triassic periods, and a relative homology between the different parts of each, i.e. the base of each is similarly coarser than the top, and each has a red phase ultimately.
2. There is a gradual gradation from coarse sediments to finer from below upwards, as in modern (and other fossil) deltas. For instance, pebbles predominate in the lower phase, coarse sandstones (with

[1] See Dr. W. Gibson, Quart. Journ. Geol. Soc., vol. lvii, pp. 251 et sqq., 1901.
[2] Dr. R. Kidston, Quart. Journ. Geol. Soc., vol. lxi, p. 318, 1905.
[3] Abstract of paper read at the British Association, Sheffield, September, 1910.

occasional pebbles) in the centre, and finer and finer marls succeed in the last phase, which becomes increasingly ferruginous, as it merges into the lake-phase of the delta period.

3. The oldest member of the series, the Bunter, is acknowledged to be a delta formation—as Professor Bonney showed many years ago—and there is no evidence for the discontinuity of the agency producing that mode of deposition.

4. The continuity of the Bunter and Keuper is an argument for the extension of delta conditions to the Keuper, some 'basement beds' being indistinguishable from the Bunter.

5. The general evidence of an oscillation of level in early Triassic times and of overlapping is a proof of aqueous agency. Coupled together these vertical and horizontal movements are more distinctive of fluviatile than lacustrine or marine conditions.

6. There is a close analogy between the contour or geographical configuration of the Trias (whether we consider concealed or exposed areas) and modern deltas, e.g. the Mississippi, with its dactyloid extensions beyond the head.

7. There is a distinct analogy between the regular alternations of pebbles or sand and marl and seasons of torrential rains and floods or drought; that is to say, one sort of sediment is brought down at one period of the year, another at another. This may be witnessed in modern accumulations such as those of the Nile or Mississippi, where floods occur. These alternations are due to overflow of banks where 'skerries' lie on the hilly grounds now, just as they did when they were deposited. The grey marl is heavier than the red, and deposits are arranged as in a diffusion column.

8. The coloration of the Trias is original; that is to say, the red colour, imparted by peroxide of iron, was deposited on sediments under water-level. But it is not continuous everywhere with the bedding. 'Catenary' bedding is thus illusory. In only one case has an anticlinal fold of red-coloured marl been noticed underlying a grey band, but, on the other hand, synclinal folds are not uncommon, as in catenary bedding, the grey (heavier) marl lying in the hollows.

9. The great thickness of the Bunter pebble beds is a proof of a subsiding area at the opening of the Trias and of conditions suitable to a gradually widening and deeper delta area.

Normally delta deposits lie at an angle of about 45 degrees with the river bed, but as they are deposited in a subsiding area these beds describe an angle of 45 degrees and *become horizontal*. Thus the absence of delta bedding (not everywhere, for it occurs in Bunter, Lower and Upper Keuper here and there) in the Trias is proof that it was deposited in a subsiding area.

The 'radial dip' around submerged areas is due to the 'angle of rest' which normally produces inclined beds. The winding of the course of a river like the Mississippi, producing wide alluvial plains, would account for the Red Marl being deposited much as in a lacustrine area.

10. There is evidence from analogy of the ferruginous nature of the Upper Coal-measures, Permian, and Trias of the delta origin of the red marls.

11. The present horizontality, the littoral or marginal dip around the hills (e.g. Charnwood Forest), with the south-easterly dip (as in the Coal-measures and Permian formation), is original.

Trias reaches a height of 880 feet on Bardon Hill and is apparently in situ. Hence the elevated tracts must have originally been under water.

Moreover, the following facts may be noted in connexion with submerged hills under the Triassic covering:—

(1) The Trias is horizontal away from the older hills, as at Hathern, Sileby, etc.

(2) It is horizontal within old gullies and fiords within the islandic area, as well as over 'saddlebacks' (anticlinal folds in older rocks, as at Longcliffe, Enderby), as at Groby, Swithland, Mount Sorrel.

(3) There is an absence of faults of any magnitude. A very slight one affects the Rhætics at Glen Parva. The older one at Bardon has no relation to the Trias.

(4) It occurs filling fissures at great heights, as at Siberia Quarry, Bardon Hill.

12. Only the sandstones or 'skerries' are rippled, not the marls, with ripples S.W. to N.E. in direction; that is, the ridges run N.W. by S.E. generally, the force moving the wind and wave thus coming from the south-west. This is to be noted all round Charnwood Forest.

13. The screes are very largely to the south-west of the submerged older rocks which they cover, and from which (as on sea-coasts dunes are formed with screes forming at the foot of cliffs) they are derived.

14. The sandstones thin out and disappear eastward (as in the Lower Keuper), the marls westward, and the sandstones or skerries are chiefly on present hilly ground (as in the past).

15. The surface features of the old elevated rocks are largely original, where not covered by the Trias. The crags of High Sharpley, Broombriggs, etc., are quite untouched. The structure of the older formation can be distinctly made out as at Hanging Rocks. Blackbrook is only an emptied Triassic fiord.

16. Desert conditions are confined to the marginal contact of the Red Marl with certain older rocks (chiefly syenites as at Croft and Mount Sorrel), and this occurs at the same level, indicating its merely local phase. Wind-polished rocks occur to the west and north of Castle Hill, Mount Sorrel.

17. There is an absence of desert conditions in the surrounding area, i.e. away from the old rocks. Only in one instance has an anticlinal fold of Red Marl, simulating a dune, been discovered, as at Sileby.

18. The beds of gypsum and rock-salt are continuous in a linear direction, and are horizontal, which must be due to aqueous depositions and brought about during the greater lagoon phase at the close of the epoch, or the contemporary marginal lagoon phase during the early period, of the delta formation.

19. There is a gradual gradation of the Keuper into the Rhætics and so into the Lias, marine conditions commencing with the Rhætics.

20. The source of the sediments is in a large measure correlated

with that of the Bunter, which was formed by a river coming from North-West Scotland.

21. There is a correspondence between the characteristics of the micropetrography of the Bunter, Keuper, and modern delta formations. The Leicestershire Trias shows signs of chemical action, the Nile delta of mechanical. The chemical composition of volcanic and metamorphic rocks locally argues a local as well as a distant source for the heavier minerals of the Keuper.

22. The evidence of the flora and fauna shows that there were provinces, and these were so arranged as to allow for the prevalence of delta conditions. The climate was moist and equable.

Finally, we conclude that there is nothing to prove that desert conditions did anything more than locally act upon the rocks mechanically, and to some extent chemically. *They had no part whatever in the work of deposition;* that is to say, they disintegrated the previous rocks (pre-Triassic). There is positive, direct, and accumulative evidence to prove that the Trias as a whole (and not the Bunter only) was the work of rivers which had continued to bring sediment in one form or another from the north-west of Britain or the north more or less continuously, under one condition or another, from the close of the marine phase of Lower Carboniferous (Mountain Limestone) times.

NOTICES OF MEMOIRS.

I.—British Association for the Advancement of Science. Sheffield, 1910. Address by the Rev. Professor T. G. Bonney, Sc.D., LL.D., F.R.S., President.[1]

. . . .

I DO not propose, as you might naturally expect, to discuss some branch of petrology; though for this no place could be more appropriate than Sheffield, since it was the birthplace and the life-long home of Henry Clifton Sorby, who may truly be called the father of that science. This title he won when, a little more than sixty years ago, he began to study the structure and mineral composition of rocks by examining thin sections of them under the microscope. A rare combination of a singularly versatile and active intellect with accurate thought and sound judgment, shrewd in nature, as became a Yorkshireman, yet gentle, kindly, and unselfish, he was one whom his friends loved and of whom this city may well be proud. Sorby's name will be kept alive among you by the Professorship of Geology which he has endowed in your University; but, as the funds will not be available for some time, and as that science is so intimately connected with metallurgy, coal-mining, and engineering, I venture to express a hope that some of your wealthier citizens will provide for the temporary deficiency, and thus worthily commemorate one so distinguished.

[1] We regret that our limited space prevents the insertion of the full text of Professor Bonney's Address. Thus the statement of facts relating to the Drifts of Britain have been omitted, but the main arguments relating to the interpretation of the phenomena have been retained.

But to return. I have not selected petrology as my subject, partly because I think that the great attention which its more minute details have of late received has tended to limit rather than to broaden our views, while for a survey of our present position it is enough to refer to the suggestive and comprehensive volume published last year by Mr. A. Harker;[1] partly, also, because the discussion of any branch of petrology would involve so many technicalities that I fear it would be found tedious by a large majority of my audience. . . . I purpose, then, to ask your attention this evening to some aspects of the glacial history of Western Europe.

. . . Much light will be thrown on this complex problem by endeavouring to ascertain what snow and ice have done in some region which, during the Glacial Epoch, was never submerged, and none better can be found for this purpose than the European Alps.

. . . .

In certain mountain regions, especially those where strong limestones, granites, and other massive rocks are dominant, the valleys are often trench-like, with precipitous sides, having cirques or corries at their heads, and with rather wide and gently sloping floors, which occasionally descend in steps, the distance between these increasing with that from the watershed. Glaciers have unquestionably occupied many of these valleys, but of late years they have been supposed to have taken a large share in excavating them. In order to appreciate their action we must imagine the glens to be filled up and the district restored to its former condition of a more or less undulating upland. As the mean temperature[2] declined snow would begin to accumulate in inequalities on the upper slopes. This, by melting and freezing, would soften and corrode the underlying material, which would then be removed by rain and wind, gravitation, and avalanche. In course of time the hollow thus formed would assume more and more the outlines of a corrie or a cirque by eating into the hillside. With an increasing diameter it would be occupied, as the temperature fell, first by a permanent snow-field, then by the *névé* of a glacier. Another process now becomes important, that called 'sapping'. While ordinary glacier-scour tends, as we are told, to produce "sweeping curves and eventually a graded slope", 'sapping' produces "benches and cliffs, its action being horizontal and backwards", and often dominant over scour. The author of this hypothesis[3] convinced himself of its truth in the Sierra Nevada. . . . Beneath the *névé* the temperature would be uniform, so its action would be protective, except where it set up another kind of erosion, presently to be noticed; but in the chasm, we are informed, there would be, at any rate for a considerable part of the year, a daily alternation of freezing and thawing. Thus the cliff would be rapidly undermined and be carried back into the mountain slope, so that before long the glacier would nestle in a shelter of its own making. Farther down the valley the

[1] *The Natural History of Igneous Rocks*, 1909.
[2] In the remainder of this Address 'temperature' is to be understood as mean temperature. The Fahrenheit scale is used.
[3] W. D. Johnson, *Science*, N.S., vol. ix, pp. 106, 112, 1899.

moving ice would become more effective than sub-glacial streams in deepening its bed; but since the *névé*-flow is almost imperceptible near the head, another agency must be invoked, that of 'plucking'. The ice grips, like a forceps, any loose or projecting fragment in its rocky bed, wrenches that from its place, and carries it away. The extraction of one tooth weakens the hold of its neighbours, and thus the glen is deepened by 'plucking', while it is carried back by 'sapping'. Streams from melting snows on the slopes above the amphitheatre might have been expected to co-operate vigorously in making it, but of them little account seems to be taken, and we are even told that in some cases the winds probably prevented snow from resting on the rounded surface between two cirque-heads.[1] As these receded, only a narrow neck would be left between them, which would be ultimately cut down into a gap or 'col'. Thus a region of deep valleys with precipitous sides and heads, of sharp ridges, and of more or less isolated peaks is substituted for a rather monotonous, if lofty, highland.

The hypothesis is ingenious, but some students of Alpine scenery think more proof desirable before they can accept it as an axiom.

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But even if 'sapping and plucking' were assigned a comparatively unimportant position in the cutting out of cirques and corries, it might still be maintained that the glaciers of the Ice Age had greatly deepened the valleys of mountain regions. That view is adopted by Professors Penck and Brückner in their work on the glaciation of the Alps,[2] the value of which even those who cannot accept some of their conclusions will thankfully admit. On one point all parties agree—that a valley cut by a fairly rapid stream in a durable rock is V-like in section. . . . It is also agreed that a valley excavated or greatly enlarged by a glacier should be U-like in section. But an Alpine valley, especially as we approach its head, very commonly takes the following form. For some hundreds of feet up from the torrent it is a distinct V; above this the slopes become less rapid, changing, say, from 45° to not more than 30°, and that rather suddenly. Still higher comes a region of stone-strewn upland valleys and rugged crags, terminating in ridges and peaks of splintered rock, projecting from a mantle of ice and snow. The V-like part is often from 800 to 1000 feet in depth, and the above-named authors maintain that this, with perhaps as much of the more open trough above, was excavated during the Glacial Epoch. Thus the floor of any one of these valleys prior to the Ice Age must often have been at least 1800 feet above its present level. As a rough estimate we may fix the deepening of one of the larger Pennine valleys, tributary to the Rhone, to have been, during the Ice Age, at least 1600 feet in their lower parts. Most of them are now hanging valleys; the stream issuing, on the level of the main river, from a deep gorge. Their tributaries are rather variable in form; the larger as a rule being more or less V-shaped; the shorter, and especially the smaller, corresponding more with the upper part

[1] This does not appear to have occurred in the Alps.
[2] *Die Alpen in Eiszeitalter*, 1909.

of the larger valleys; but their lips generally are less deeply notched. Whatever may have been the cause, this rapid change in slope must indicate a corresponding change of action in the erosive agent. Here and there the apex of the V may be slightly flattened, but any approach to a real U is extremely rare. The retention of the more open form in many small, elevated recesses, from which at the present day but little water descends, suggests that where one of them soon became buried under snow, but was insignificant as a feeder of a glacier, erosion has been for ages almost at a standstill.

The V-like lower portion in the section of one of the principal valleys, which is all that some other observers have claimed for the work of a glacier, cannot be ascribed to subsequent modification by water, because ice-worn rock can be seen in many places, not only high up its sides, but also down to within a yard or two of the present torrent.

Thus valley after valley in the Alps seems to leave no escape from the following dilemma: Either a valley cut by a glacier does not differ in form from one made by running water, or one which has been excavated by the latter, if subsequently occupied, is but superficially modified by ice.

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Many lake-basins have been ascribed to the erosive action of glaciers. Since the late Sir A. Ramsay advanced this hypothesis numbers of lakes in various countries have been carefully investigated and the results published, the most recent of which is the splendid work on the Scottish lochs by Sir J. Murray and Mr. L. Pullar.[1] . . . Even these latest researches have not driven me from the position which I have maintained from the first—namely, that while many tarns in corries and lakelets in other favourable situations are probably due to excavation by ice, as in the mountainous districts of Britain, in Scandinavia, or in the higher parts of the Alps, the difficulty of invoking this agency increases with the size of the basin—as, for example, in the case of Loch Maree or the Lake of Annecy—till it becomes insuperable. Even if Glas Llyn and Llyn Llydaw were the work of a glacier, the rock-basins of Gennesaret and the Dead Sea, still more those of the great lakes in North America and in Central Africa, must be assigned to other causes.

I pass on, therefore, to mention another difficulty in this hypothesis—that the Alpine valleys were greatly deepened during the Glacial Epoch—which has not yet, I think, received sufficient attention. From three to four hundred thousand years have elapsed, according to Penck and Brückner, since the first great advance of the Alpine ice. One of the latest estimates of the thickness of the several geological formations assigns 4000 feet[2] to the Pleistocene and Recent, 13,000 to the Pliocene, and 14,000 to the Miocene. If we assume the times of deposit to be proportional to the thicknesses, and adopt the larger figure for the first-named period, the duration of the Pliocene would

[1] *Bathymetrical Survey of the Scottish Freshwater Lochs*, by Sir J. Murray and Mr. L. Pullar, 1910.

[2] I have doubts whether this is not too great.

be 1,300,000 years, and of the Miocene 1,400,000 years. To estimate the total vertical thickness of rock which has been removed from the Alps by denudation is far from easy, but I think 14,000 feet would be a liberal allowance, of which about one-seventh is assigned to the Ice Age. But during that age, according to a curve given by Penck and Brückner, the temperature was below its present amount for rather less than half (·47) the time. Hence it follows that, since the sculpture of the Alps must have begun at least as far back as the Miocene period, one-seventh of the work has been done by ice in not quite one-fifteenth of the time, or its action must be very potent. Such data as are at our command make it probable that a Norway glacier at the present day lowers its basin by only about 80 millimetres in 1000 years, a Greenland glacier may remove some 421 millimetres in the same time, while the Vatnajökul in Iceland attains to 647 millimetres. If Alpine glaciers had been as effective as the last-named, they would not have removed, during their 188,000 years of occupation of the Alpine valleys, more than 121·6 metres, or just over 397 feet; and as this is not half the amount demanded by the more moderate advocates of erosion, we must either ascribe an abnormal activity to the vanished Alpine glaciers, or admit that water was much more effective as an excavator.

We must not forget that glaciers cannot have been important agents in the sculpture of the Alps during more than part of Pleistocene times. That sculpture probably began in the Oligocene period; for rather early in the next one the great masses of conglomerate, called *Nagelfluh*, show that powerful rivers had already carved for themselves valleys corresponding generally with and nearly as deep as those still in existence. Temperature during much of the Miocene period was not less than 12° F. above its present average. This would place the snow-line at about 12,000 feet.[1] In that case, if we assume the altitudes unchanged, not a snow-field would be left between the Simplon and the Maloja, the glaciers of the Pennines would shrivel into insignificance, Monte Rosa would exchange its drapery of ice for little more than a tippet of frozen snow. As the temperature fell the white robes would steal down the mountain-sides, the glaciers grow, the torrents be swollen during all the warmer months, and the work of sculpture increase in activity. Yet with a temperature even 6° higher than it now is, as it might well be at the beginning of the Pliocene period, the snow-line would be at 10,000 feet; numbers of glaciers would have disappeared, and those around the Jungfrau and the Finster Aarhorn would be hardly more important than they now are in the Western Oberland.

But denudation would begin so soon as the ground rose above the sea. Water, which cannot run off the sand exposed by the retreating tide without carving a miniature system of valleys, would never leave the nascent range intact. The Miocene Alps, even before a patch of

[1] I take the fall of temperature for a rise in altitude as 1° F. for 300 feet, or, when the differences in the latter are large, 3° per 1000 feet. These estimates will, I think, be sufficiently accurate. The figures given by Hann (see for a discussion of the question, Report of Brit. Assoc., 1909, p. 93) work out to 1° F. for each 318 feet of ascent (up to about 10,000 feet).

snow could remain through the summer months, would be carved into glens and valleys. Towards the end of that period the Alps were affected by a new set of movements, which produced their most marked effects in the northern zone from the Inn to the Durance. The Oberland rose to greater importance; Mont Blanc attained its primacy; the massif of Dauphiné was probably developed. That, and still more the falling temperature, would increase the snow-fields, glaciers, and torrents. The first would be, in the main, protective; the second, locally abrasive; the third, for the greater part of their course, erosive. No sooner had the drainage system been developed on both sides of the Alps than the valleys on the Italian side (unless we assume a very different distribution of rainfall) would work backwards more rapidly than those on the northern. Cases of trespass, such as that recorded by the long level trough on the north side of the Maloja Kulm and the precipitous descent on the southern, would become frequent. In the Interglacial episodes—three in number, according to Penck and Brückner, and occupying rather more than half the epoch—the snow and ice would dwindle to something like its present amount, so that the water would resume its work. Thus I think it far more probable that the V-like portions of the Alpine valleys were in the main excavated during Pliocene ages, their upper and more open parts being largely the results of Miocene and yet earlier sculpture.

During the great advances of the ice, four in number, according to Penck and Brückner,[1] when the Rhone glacier covered the lowlands of Vaud and Geneva, welling on one occasion over the gaps in the Jura, and leaving its erratics in the neighbourhood of Lyons, it ought to have given signs of its erosive no less than of its transporting power. But what are the facts? In these lowlands we can see where the ice has passed over the Molasse (a Miocene sandstone); but here, instead of having crushed, torn, and uprooted the comparatively soft rock, it has produced hardly any effect. The huge glacier from the Linth Valley crept for not a few miles over a floor of stratified gravels, on which, some 8 miles below Zurich, one of its moraines, formed during the last retreat, can be seen resting, without having produced more than a slight superficial disturbance. We are asked to credit glaciers with the erosion of deep valleys and the excavation of great lakes, and yet, wherever we pass from hypotheses to facts, we find them to have been singularly inefficient workmen!

I have dwelt at considerable, some may think undue, length on the Alps, because we are sure that this region from before the close of the Miocene period has been above the sea-level. It accordingly demonstrates what effects ice can produce when working on land.

In America also, to which I must now make only a passing reference, great ice-sheets formerly existed: one occupying the district west of the Rocky Mountains, another spreading from that on the north-west of Hudson's Bay, and a third from the Laurentian hill-country. These two became confluent, and their united ice-flow covered the region of the Great Lakes, halting near the eastern coast a little south

[1] On the exact number I have not had the opportunity of forming an opinion.

of New York, but in Ohio, Indiana, and Illinois occasionally leaving moraines only a little north of the 39th parallel of latitude. Of these relics my first-hand knowledge is very small, but the admirably illustrated reports and other writings of American geologists indicate that, if we make due allowance for the differences in environment, the tills and associated deposits on their continent are similar in character to those of the Alps.

In our own country and in corresponding parts of Northern Europe we must take into account the possible co-operation of the sea. In these, however, geologists agree that, for at least a portion of the Ice Age, glaciers occupied the mountain districts. Here ice-worn rocks, moraines and perched blocks, tarns in corries, and perhaps lakelets in valleys, demonstrate the former presence of a mantle of snow and ice. Glaciers radiated outwards from more than one focus in Ireland, Scotland, the English Lake District, and Wales, and trespassed, at the time of their greatest development, upon the adjacent lowlands. They are generally believed to have advanced and retreated more than once, and their movements have been correlated by Professor J. Geikie with those already mentioned in the Alps. Into that very difficult question I must not enter; for my present purpose it is enough to say that in early Pleistocene times glaciers undoubtedly existed in the mountain districts of Britain and even formed piedmont ice-sheets on the lowlands. On the west side of England, smoothed and striated rocks have been observed near Liverpool, which can hardly be due to the movements of shore-ice. . . . On the eastern side of England similar markings have been found down to the coast of Durham, but a more southern extension of land ice cannot be taken for granted. In this direction, however, so far as the tidal valley of the Thames, and in corresponding parts of the central and western lowlands, certain deposits occur which, though to a great extent of glacial origin, are in many respects different from those left by land ice in the Alpine regions and in Northern America.

They present us with problems the nature of which may be inferred from a brief statement of the facts.[1]

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

II.—British Association for the Advancement of Science, Eightieth Annual Meeting, held at Sheffield, September 1–7, 1910. List of Titles of Papers read in Section C (Geology) and in other Sections bearing upon Geology.

Presidential Address by *Dr. A. P. Coleman, F.R.S.*

Cosmo Johns.—The Yoredale Series and its equivalents elsewhere.

Dr. J. E. Marr, F.R.S., & W. G. Fearnsides, M.A.—The Palæozoic Rocks of Cautley (Sedbergh).

Miss G. R. Watney & Miss E. G. Welch.—The Graptolitic Zones of the Salopian Rocks of the Cautley Area (Sedbergh).

Professor J. Joly, D.Sc., F.R.S.—Pleochroic Halos.

[1] See footnote on p. 463, at the commencement of the President's Address.

Dr. J. D. Falconer.—Outlines of the Geology of Northern Nigeria.
Dr. F. H. Hatch.—The Geology of Natal.
Cosmo Johns.—The Geology of the Sheffield District.
Professor A. McWilliam.—The Metallurgical Industries in relation to the Rocks of the District.
T. Sheppard.—The Humber during the Human Period.
Dr. Tempest Anderson.—Matavanu, a new Volcano in Savaii (German Samoa).
Rev. E. C. Spicer, M.A.—On present Trias Conditions in Australia.
Dr. Wm. H. Hobbs.—Some considerations concerning the Alimentation and the Losses of existing Continental Glaciers.
Dr. J. Milne, F.R.S.—Seismological Report.
Mrs. M. M. Ogilvie Gordon, D.Sc.—Thrust Masses in the Western District of the Dolomites.
Professor J. W. Gregory, D.Sc., F.R.S.—On the Geology of Cyrenaica.
Marmaduke Odling.—An Undescribed Fossil from the Chipping Norton Limestone.
Professor Edward Hull, LL.D., F.R.S.—The Glacial Rocks of Ambleside.
Dr. C. H. Lees, F.R.S.—Mountain Temperatures and Radium.
John Parkinson.—Notes on the Geology of the Gold Coast.
A. D. Hall, F.R.S., & Dr. E. J. Russell.—The Objects and Scope of Soil Surveys.
L. F. Newman.—Drift Soils of Norfolk.
C. T. Cimingham.—The Teart Land of Somerset.
Sir T. H. Holland, F.R.S.—The Cause of Gravity Variations in Northern India.
Discussion on the concealed Coal-field of Notts, Derbyshire, and Yorkshire. Opened by *Professor P. F. Kendall, M.Sc., & Dr. Walcot Gibson.*
H. Culpin.—The Marine Bands in the Coal-measures of South Yorkshire.
W. H. Dyson.—The Maltby Deep Boring.
Miss M. C. Stopes, D.Sc., Ph.D.—Structural Petrifactions from the Mesozoic, and their bearing on Fossil Plant Impressions.
Dr. L. Moysey.—On some Rare Fossils from the Derbyshire and Notts Coal-field.
A. R. Horwood.—The Origin of the British Trias.
Rev. A. Irving, D.Sc., B.A.—On a Buried Tertiary Valley through the Mercian Chalk Range, and its later "Rubble Drift", etc.
Cosmo Johns.—The Geological Significance of the Nickel-Iron Meteorites.
Ernest Dixon, B.Sc.—The Geology of the Titterstone Clee Hills.
Reports on—
Erratic Blocks.
Crystalline Rocks of Anglesey.
Faunal Succession in the Carboniferous Limestone.
Critical Sections in the Palæozoic Rocks.
Charnwood Rocks.
Rocks of Glensaul.
Correlation and Age of South African Strata.

Geological Photographs.
Fossil Flora and Fauna of the Midland Coal-fields.
Topographical and Geological Terms used locally in South Africa.
Dr. A. Irving, D.Sc., B.A.—The pre-Oceanic Stage of Planetary Development.

List of Titles of papers read in other Sections bearing upon Geology :—

SECTION A.—PHYSICAL SCIENCE.

Sir Norman Lockyer, K.C.B.—Chemistry of the Stars.

SECTION E.—GEOGRAPHY.

O. G. S. Crawford.—A Regional Survey of the Andover District.
J. Cossar.—A Regional Survey of Midlothian.
H. Brodrick.—The Underground Waters of the Castleton District.
Dr. C. A. Hill.—Further Exploration in the Mitchelstown Cave.

SECTION H.—ANTHROPOLOGY.

Presidential Address by *W. Crooke, B.A.*
A. M. Woodward & H. A. Ormerod.—A Primitive Site in South-West Asia Minor.
A. J. B. Wace & M. S. Thompson.—Excavations in Thessaly.
Professor R. C. Bosanquet.—The work of the Liverpool Committee for Excavation and Research in Wales and the Marches.
Professor W. M. Flinders Petrie.—The Excavations at Memphis.
Dr. C. G. Seligmann.—On a Neolithic Site in the Southern Sudan.
Dr. T. Ashby.—Excavations at Hagiar Kim and Mnaidra, Malta.
H. D. Acland.—Prehistoric Monuments in the Scilly Isles.
Alexander Sutherland.—On the Excavation of the Broch of Cogle, Watten, Caithness.
G. Clinch.—Unexplored Fields in British Archæology.
Report of a Committee to investigate the Lake Villages in the neighbourhood of Glastonbury.
Report of a Committee to ascertain the Age of Stone Circles.
Rev. Dr. Irving.—On a Prehistoric Horse found at Bishop's Stortford.

SECTION K.—BOTANY.

Professor F. O. Bower.—Semi-popular lecture on Sand-dunes and Golf-links.
Professor F. O. Bower.—On two Synthetic Genera of Filicales.
Professor D. T. Gwynne-Vaughan.—On the Fossil genus *Tempskya.*
Dr. M. C. Stopes.—Further Observations on the Fossil Flower.

ABSTRACTS OF PAPERS READ IN SECTION C (GEOLOGY) AT THE MEETING OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, SHEFFIELD, SEPTEMBER 1, 1910.

III.—THE COAL-MEASURES OF THE CONCEALED YORKSHIRE, NOTTINGHAMSHIRE, AND DERBYSHIRE COAL-FIELD. By WALCOT GIBSON, D.Sc.

ON the map accompanying Mr. Currer Brigg's Report on District D in the Final Report of the Royal Commission on Coal Supplies for 1905 a triangular area having its apex at the Haxey (South Carr) boring is marked off as the proved extent of the concealed coal-field. The area thus defined amounts to about 460 square miles. To this, as the result of information obtained from several borings for coal completed since 1905, there can be added about 200 square miles situated north-east of Haxey and about 200 square miles lying south-east of Haxey. Much information has also been collected in the proved coal-field. The new material, so far as it relates to the Coal-measures, may be considered under (1) shape of the Palæozoic floor, (2) character of the measures, (3) the workable seams that are likely to occur within 4000 feet depth, and (4) their probable extension beyond the limits considered as proved in the Report of 1905.

1. *Palæozoic Floor.*—Between the outcrop of the Magnesian Limestone and the River Trent, north of Nottingham, the Permian rests on a uniform plain with a slope not exceeding two degrees and having a general direction to the east or a little north of east. Over the faulted area, south of Nottingham, the uniformity of slope has been broken; but outside the faulted belt the same even surface is maintained between Ruddington, Edwalton, and Owthorpe.

2. *Character of the Measures.*—The Barlow (Selby) boring in the north, the Thorne boring in the east, and that of Owthorpe in the south show that the Coal-measures immediately beneath the newer formations belong to an horizon several hundred feet above the Top Hard or Barnsley Coal, which is a high and most valuable seam in the coal-field. In these measures a marine band (20 to 50 feet thick) lies between 520 feet (Oxton boring) and 629 feet (Mansfield Colliery) above the Top Hard Coal in Nottinghamshire, and, as ascertained by Mr. Culpin at Brodsworth and Bentley and by Mr. Dyson at Maltby, between 670 and 705 feet above the Barnsley Coal in Yorkshire. The fauna, exclusively marine, is represented by fifty species distributed among thirty-seven genera. Many of the forms occur in the shales below the Millstone Grits, and a few represent survivors from the Carboniferous Limestone. The persistence, thickness, and fauna of the bed indicate a general and a fairly prolonged incursion of the open sea during late Middle Coal-measures. Minor incursions are represented by a few thin beds occurring above and below this horizon in Nottinghamshire and Yorkshire. The thickness of the measures as a whole increases to the north and diminishes to the east.

3. *The Workable Seams.*—All the borings and sinkings strike Coal-measures above the chief marine bed; but, except at Oxton and Maltby, both situated in the proved coal-field, the Upper Coal-measures have been completely removed by pre-Permian denudation. The seams above the Top Hard Coal and Barnsley Coal are irregular in their occurrence and of uncertain quality. In the Doncaster and Thorne area the Dunsil Coal 50 feet below the Barnsley bed appears to be a valuable seam, but it deteriorates south of Doncaster. Most of the lower coals over the recently proved extension of the coal-field lie beyond the limit of profitable working. The future resources of the coal-field therefore mainly depend upon the thickness, quality, and depth of the Top Hard or Barnsley Coal.

4. *Extension.*—As a result of the explorations made since the Report of 1905 the proved limit of the concealed coal-field may with some

confidence be extended to a line joining Selby, Thorne, Haxey, and Owthorpe, but the quality and thickness of the coal cannot be foretold. There is no conclusive evidence to show whether, north of Thorne, the Barnsley Coal will take on the inferior character which it assumes north-east and east of Wakefield under the name of the Warren House Coal, and whether the thinning out of the Top Hard Coal observable in some of the collieries south of Mansfield will continue to the east.

A further extension north of the Ouse, east of the Trent, and south-east of Owthorpe is probable, but it is important to bear in mind how much there must be of conjecture in any conclusions arrived at from the slender evidence at present available.

IV.—The Graptolitic Zones of the Salopian Rocks of the Cautley Area near Sedbergh, Yorkshire. By Miss G. R. Watney and Miss E. G. Welch.

We have obtained the following zones in the Ludlow Rocks in descending order:—

1. *Monograptus leintwardinensis* (Hopk.)	Lower Bannisdale Slates.
2. *Monograptus Nilssoni* (Barr.)	Coniston Grits. U. Coldwell Beds.
3. *Monograptus vulgaris* (Wood)	M. Coldwell Beds.

In the Wenlock the following zones have been found in descending order:—

1. *Cyrtograptus Lundgreni* (Tullb.)	L. Coldwell Beds. Brathay Flags.
2. *Cyrtograptus Linnarssoni* (Lapw.) *Cyrtograptus symmetricus* (Elles)	Brathay Flags.
3. *Monograptus riccartonensis* (Lapw.)	Brathay Flags.
4. *Cyrtograptus Murchisoni* (Carr)	Brathay Flags.

These zones are comparable with those discovered by Miss Elles[1] and Mrs. Shakespear[1] in Wales and the Welsh Borderland[1]; though we have not yet succeeded in finding all the zones which they record we hope shortly to establish them in this area.

V.—Structural Petrifactions from the Mesozoic, and their bearing on Fossil Plant Impressions. By Miss M. C. Stopes, D.Sc., Ph.D., F.L.S.

The paper dealt with the importance of the structural petrifactions in the Carboniferous, e.g. exposure of the true nature of so many supposed 'ferns'; with the need of similar petrifactions from beds of Mesozoic age; and the danger of inferences drawn from plant *impressions*, e.g. untrustworthiness of many of Heer's and Ettingshausen's systematic determinations.

The discovery of true petrifactions in the Cretaceous, the nature of the flora contained in the nodules, and unusual points in its composition were considered. Special illustrations of its interest are: *Yezonia*, a new type of which the external appearance gives no clue to its nature; the discovery of the first-known flower with its anatomy petrified; and of the internal anatomy of the leaves of *Nilssonia*, long well known as impressions.

[1] Q.J.G.S., 1900.

VI.—Notes on the Lower Palæozoic Rocks of the Cautley District, Sedbergh, Yorks. By J. E. Marr, Sc.D., F.R.S., and W. G. Fearnsides, M.A., F.G.S.

The general succession is well known. The following additions to our knowledge of the various divisions have been recently obtained by us:—

Salopian.—Divisible into Lower Ludlow Rocks (Bannisdale Slates, Coniston Grits, and Coldwell Beds) above, and Wenlock Rocks (Brathay Flags) below. The calcareous gritty flags with *Phacops obtusicaudatus* are found here at the base of the Coldwell Beds, and form a ready line of separation between the Ludlow and Wenlock graptolitiferous strata. The Salopian graptolitic zones are being worked out by Miss G. R. Watney and Miss E. G. Welch.

Valentian.—The succession as described by one of us with the late Professor Nicholson was incomplete. We have now found a section in Watley Gill which nearly completes the sequence. In that beck the *Monograptus argenteus*, *M. fimbriatus*, and *Dimorphograptus* zones of the Skelgill Beds are found with their intercalated Trilobite beds, the higher graptolitic zones being absent owing to a fault which repeats the *Dimorphograptus* beds. The *argenteus* zone contains the type fossil and its usual associates, and exhibits the 'green streak' seen in the Lake District and in North Wales.

Ashgillian.—The Ashgill Shales have long been known here. The basal *Staurocephalus* Limestone appears to be represented by a greyish argillaceous limestone in Taith's Gill, which succeeds the Caradocian rocks with perfect conformity, and yields abundance of *Remopleurides radians* and other fossils; also by a similar limestone in the same position in Backside Beck, with badly preserved Trilobites, etc.

Caradocian.—Black calcareous shales with their argillaceous limestones containing a very rich Caradocian fauna, recalling that of the Trinucleus Shales of Sweden. The fauna is being worked at and separated from that of the Ashgillian Beds.

VII.—On some Rare Fossils from the Derbyshire and Nottinghamshire Coal-field. By L. Moysey, B.A., M.B., B.C., F.G.S.

In the temporary museum in connexion with this section there will be found a collection of fossils illustrating some of the rarer forms of the Coal-measure fauna obtained during the last eight years from this district. From these it has been thought desirable to select some, mainly fragmentary specimens, for more detailed description, in the hope that they may be of assistance in the identification of other more perfect specimens, should such be obtained, and that a discussion on their many perplexing features may lead to a more definite idea as to their affinities.

Specimen 1, from Shipley, near Ilkeston, Derbyshire. These minute bodies, about 3 mm. long, are evidently the valves of the carapace of a Phyllopod. A similar fossil was described by Lea[1] from Pennsylvania under the name of *Cypricardia leidyi*. Professor T.

[1] Proc. Acad. Nat. Sc. Philadelphia, vol. vii, pt. iv, p. 341, 1855.

Rupert Jones[1] gave it the name of *Leaia leidyi*, and described two varieties, one *L. leidyi* var. *Williamsoniana*, from Ardwick, near Manchester, and the other *L. 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 trigonoides*, sp. nov., rather than risk confusion by adding a varietal appellation.

Specimen 2, from Shipley, is of interest, owing to the great difficulty of its interpretation. Possibly the best explanation is that it is the glabellar region of a *Prestwichia*. The presence of two minute crescentic dots, one on each side of the median line, is in favour of this theory, on the assumption that they are the larval eyes of the animal. Dr. Henry Woodward, however, who has examined this specimen, is very doubtful as to its limuloid origin.

Specimen 3, from the Kilburn Coal, Trowell Colliery, Notts. The curious feature in this specimen is the presence of crescentic openings on each segment similar to the 'stigmata' found in scorpions and other Arachnids, suggesting that it may be a fragment of an air-breathing animal.

Specimen 4, from Shipley, is probably one of the first abdominal segments of *Eoscorpius* sp., two specimens of which genus have been found in this district—one from near Chesterfield, and another, at present undescribed, found by the author in the Digby Claypit, Kimberley, Notts.

Specimen 5, from Brindsley, Notts, is a single segment of an Arthropod, and possibly referable to *Eurypterus*.

Specimen 6, from Shipley, is the wing of an insect probably belonging to the order Palæodictyoptera of Scudder.

Specimens 7 and 8, also from Shipley, are a fragment of a much smaller insect's wing, which, in its incomplete state, would be impossible to assign to any definite order.

Insects' wings are very uncommon in the Coal-measures of this district, only one having been found near Chesterfield, and described by S. H. Scudder[2] under the name *Archæoptilus ingens*.

REVIEWS.

I.—A Great Catalogue of Books on the Natural Sciences.

British Museum (Natural History).—Catalogue of the Books, Manuscripts, Maps, and Drawings in the British Museum (Natural History). Vol. III. L–O. By Bernard Barham Woodward. 4to. London, 1910. pp. 1039–1494. Price £1 per volume.

In September, 1903, we had the pleasure to announce the publication of the first volume of this work from A–D. Volume II (E–K) followed in 1904, and progress since then has been seriously hampered

[1] Mon. Pal. Soc., 1862, Appendix, p. 115, pl. i, fig. 21, etc.

[2] S. H. Scudder, "Haxapod Insects of Great Britain": Mem. Boston Nat. Hist. Soc., vol. iii, pp. 217–18, 1873–94.

by the great increase in current library work common to all libraries. We are, however, thankful to receive Volume III, for now we are well past the middle of the work, and the whole cannot be much longer delayed. The present volume is even better than its predecessors, and in many points is better than anything of the kind that has been done before. The same wealth of bibliographic detail is observed whenever necessary, as may be seen under C. F. P. Martius, François Levaillant, and Martin Lister for example; the same intelligent and uniform rendering of Russian names is employed; and careful attention is called to many bibliographic subtilties, so puzzling to the lay mind. Full details of books of travel are given, as for instance under Middendorff, where the separate papers are properly listed out and the dates given, and exact dates are furnished (we believe for the first time) of such troublesome books as the Naturalist's Library, which was reprinted again and again as the supply ran short. That part of the Catalogue dealing with Linnæus is one of which any librarian might be proud. It is a *tour de force*, and was, we believe, issued specially as a separate for the celebration in honour of the great naturalist in Stockholm three years ago.

A brief Preface by Mr. Fletcher reminds us that Mr. Woodward has continued to profit by the assistance of his colleagues on the staff, his valued attendant Mr. Hadrill, his clerical assistant Mrs. Wilson, and other friends, but the inception and carrying through of this invaluable book is due to himself, and those who use it and recognize its utility can hardly find words to properly express their thanks to him. What the value of a Catalogue like this must be to those smaller libraries who can never hope to amass such a collection or to get access to such reference books whereby such a collection can be properly catalogued we do not know; all we hope is that the Trustees of the British Museum having issued such a book, librarians will avail themselves of the privilege and secure it.

II.—The Earthquake of 1872 in the Owens Valley, California. By Professor W. H. Hobbs. Beiträge zur Geophysik, vol. x, pp. 352–85, 1910.

THE Owens Valley earthquake of March 26, 1872, is one of the greatest and most interesting of Californian earthquakes, and, in writing its history, Professor Hobbs has supplied a long-felt want, and supplied it well. The principal sources of his information are Whitney's almost inaccessible report published in 1872, from which he makes several interesting extracts, and the valuable maps and photographs of the fault-scarps obtained by Mr. Willard D. Johnson during his survey of the district in 1907. Though the natural tendency of fault-scarps formed during earthquakes is to lose their sharpness and eventually to become effaced, many of them are still recognizable. Those along which movements took place in 1872 run along the west side of the Owens Valley at the foot of the Alabama Hills for a total distance of about forty miles. For considerable distances, generally one or two miles, the individual scarps maintain a nearly constant direction, but at intervals they are subject to abrupt changes of direction so as to form a series of zigzags with sharp elbows. In places the faults run in parallel lines, the ends overlapping for short distances. All scarps, which are not much worn away, are steeply inclined and appear to be the continuations of nearly vertical faults. The highest measured vertical displacement along any scarp is 23 feet. Abrupt variations, and even reversal in throw are, however, occasionally seen. Horizontal displacements were also observed, though the evidence of such displacements is now almost obliterated. One of 15 feet towards the north was measured by Gilbert eleven years after the earthquake, and another of 9 feet was photographed by Mr. Johnson.

C. D.

III.—Brief Notices.

1. "The Sand-Dunes of the Libyan Desert" are described and illustrated by Mr. H. J. Llewellyn Beadnell (*Geograph. Journ.*, April, 1910). In his opinion the material has been derived from the arenaceous formations of post-Middle Eocene age that lie to the north. The dunes consist mainly of silica, but in places they contain rather more than 7 per cent. of limestone granules. As the author remarks, "In some localities extensive and prosperous settlements have been overwhelmed and blotted out of existence, while in others the sand and dust-laden winds have been of positive benefit to the inhabitants. In the south part of the oasis of Kharga, for instance, broad terraces of cultivable loam have been gradually built up in the neighbourhood of the wells, the deposition of the wind-borne material being encouraged on account of its valuable fertilizing properties." The subject is therefore of considerable economic importance as well as scientific interest. The author's observations show that the dunes progress steadily southwards at an average rate of 15 or 16 metres a year.

2. Landslides in the San Juan Mountains, Colorado, form the subject of a memoir by Mr. Ernest Howe (Professional Paper 67, U.S. Geol. Survey, Washington, 1907). It is well illustrated, and contains much information of general interest and importance.

The topography of the San Juan Mountains is described as "that of a dissected and glaciated plateau of more or less horizontally bedded volcanic rocks resting upon a foundation of sedimentary rocks". The oldest rocks, which are pre-Cambrian, are covered unconformably by various Palæozoic and Mesozoic formations, and by the Telluride conglomerate that is perhaps of Eocene age. The Tertiary volcanic rocks, with an aggregate thickness of "many thousands of feet" in the central part of the mountains, rest on the Telluride conglomerate or on a floor of older rocks, the dip of which is southerly, westerly, or northerly. Various forms of rock-falls, landslips, and soil-slips are described, all the rocks being liable to be affected. The superficial movements of the ground comprise earth-slides or soil-slips, mud-flows, and talus slumps. Other movements, though less common, are due to movement along bedding-planes in the direction of the dip. The primary jointing and secondary shattering of the rocks has led to rock-falls. Further, the oversteepness of the valley-walls that existed in a great many places after the final retreat of the ice of the Glacial epoch has had a potent influence on landslides. Earthquakes in some instances have been the immediate cause of the breaking away of rock-masses.

The author draws particular attention to 'rock streams', which have certain features in common, both with landslides and ordinary talus. In general appearance these accumulations resemble long tongues or lobes of talus stretching far out from the base of the cliffs from which they were derived, over the nearly level or gently sloping floors of the glacial cirques. The deposits are usually bounded by a sharply defined steep front; their surfaces are marked by irregular hummocks or wave-like ridges; and the material consists of angular blocks of rock, averaging about one foot in diameter, with finer and coarser material. They characterize tracts where the rocks are much shattered. Ice and snow may have influenced the formation of these rock-streams, but the author "believes that they are strictly landslides and owe their present form entirely to the nature of their fall and to the character or physical condition of the rocks involved in the fall". They appear in the main to be due to the rapid slipping of surface material.

3. The Journal of Geology (Chicago) maintains its reputation for original essays on subjects of wide interest and importance. In the number for May–June, 1910, Mr. E. S. Bastin writes on the "Origin of the Pegmatites of Maine", and concludes that the broader field-relations suggest that the large areas characterized by pegmatite intrusions constitute in reality the roofs overlaying granite batholiths. Mr. S. R. Capps, jun., deals with the "Rock Glaciers in Alaska". These are formed of angular talus and occupy cirques, or the bottoms of cirque-like valleys, that were excavated at the time of the maximum glaciation of the region. Small glaciers still exist at the heads of some of the valleys, but in most cases conditions for ordinary glacial activity have ceased, the winter's snows having all melted away during the summer. The base of the talus, however, has been filled with interstitial ice, and the movement of the mass in a glacier-like way has continued. In some respects these 'rock glaciers' are allied to the 'rock streams' described by Mr. Ernest Howe as essentially due to surface landslides. In the number for July–August, Mr. H. M. Eakin contributes an article on "The Influence of the Earth's Rotation upon the Lateral Erosion of Streams"; and Mr. R. E. Hore writes "On the Glacial Origin of Huronian Rocks of Nipissing, Ontario".

4. American Philosophical Society.—In the Proceedings for January to April, 1910 (vol. xlix, pp. 57–129) there is an important memoir by Mr. W. H. Hobbs on "Characteristics of the Inland Ice of the Arctic Regions". The author contrasts the physical conditions of the North and South Polar areas, and the differences between mountain and continental glaciers. The ice-cap glacier, while of smaller dimensions than the true inland ice or the continental glacier, is regarded as distinctly allied with this type, having few affinities with mountain glaciers. Descriptions are given of the ice-cap glaciers of Norway and Iceland, of the ice-covered archipelago of Franz Josef

Land, of the inland ice of Spitzbergen, and of the continental glacier of Greenland. The englacial and subglacial drainage, the marginal lakes, the fresh water or 'submarine wells' in fiord heads, and the discharge of bergs, are likewise described; and the subject is well illustrated by diagrams and pictorial views.

In the number for July, 1910, Mr. W. J. Sinclair records the discovery of bones of *Paramylodon* in the Pleistocene asphalt deposits near Los Angeles. Mr. T. J. J. See gives the "Results of Recent Researches in Cosmical Evolution", believing that the planets were developed in the solar nebula, and that our moon was originally a planet which became a satellite, but was never part of the terrestrial globe.

5. We have received a copy of the sixth edition of the useful *Tables for the Determination of Minerals by Physical Properties*, by Dr. Persifor Frazer and Professor A. P. Brown. (London and Philadelphia, J. B. Lippincott Co., 1910.)

CORRESPONDENCE.

YORKSHIRE GEOLOGISTS AND EDITORS.

Sir,—Would the Hull Geological Society kindly inform us of what possible use it is to publish generic names under the combinations of letters quoted below?

Psil.	Cor.	Ast.	Echi.
Cal.	Agas.	Nicro.	Der.
Schlot.	Arn.	Ambly.	Polym.
Ver.	Arie.	Oxyn.	Upt.

We doubt whether one person in a hundred has the remotest idea what they mean. It is impossible for the Recorder to waste his time looking them up, and work presented in such a way can only be disregarded.

While in the critical mood we should also like to ask whether the table on the distribution of *Belemnites* in the Lias is the result of personal collecting or of collation of printed data? If the latter, it is of little value. If the former, it would be interesting to know who is the authority for the determination of Simpson's species. What really valuable work Yorkshire geologists might do if some competent man would go and draw and describe Simpson's types in the same way as Mr. Buckman is doing for the Ammonites!

Recorder.

LYME REGIS CHURCH.

Sir,—The ancient and historic church of St. Michael, Lyme Regis, which is a good example of fifteenth century Perpendicular Gothic, is in danger owing to the encroachment of the sea. The cliffs of the district are of Blue Lias and crumble readily. Many can remember when two fields stretched between the churchyard and the edge of the cliff; but to-day not only have these disappeared, but a portion of the churchyard has gone also, and the church itself is now only 80 feet from the cliff-edge.

Mr. Francis Fox, of Sir Douglas Fox & Partners, 56 Moorgate Street, has made a gratuitous report out of goodwill towards a parish which is by no means wealthy. He explains that the trouble is due to loss of material through infiltration of the water, as the graveyard for a depth of 10 to 15 feet is composed of light porous material. He proposes a system of rubble drains, and at the foot of the cliff a reinforced concrete wall to prevent further erosion of the limestone beds.

The work will cost £2000, and a local committee has been formed. Already about £1200 has been received. Donations may be sent to the Vicar, the Rev. W. Jacob, or to Mr. J. E. Hill, Wilts and Dorset Bank, Lyme Regis.

A. C. G. Cameron.

Lyme Regis.

MISCELLANEOUS.

The Prehistoric Lake-dwellings, Glastonbury.—A full description of the recent excavations at the Glastonbury prehistoric lake-village is to be published by the Glastonbury Antiquarian Society. It is being prepared by Mr. Arthur Bulleid, the discoverer of the site, and Mr. Harold St. George Gray. Dr. Robert Munro is contributing an introductory chapter, and amongst other contributors will be Dr. Boyd Dawkins, Dr. C. W. Andrews, and Mr. Clement Reid.

A Centenarian Geologist.—Mr. John Randall, of Madeley, Shropshire, has this year celebrated his 100th birthday, having been born at Ladywood, Broseley, on September 1, 1810. Mr. Randall (with George E. Roberts) read before the Geological Society in January, 1863, a paper "On the Upper Silurian Passage-beds at Linley, Salop"; and in the following month he was elected a Fellow of the Society, but resigned in 1877. Several geological communications from Mr. Randall have appeared in the Geological Magazine. We learn from the *Shrewsbury Chronicle* that he received a bronze medal for his collection of minerals and fossils at the Great Exhibition of 1851. He was connected with the Coalport pottery works from 1833 to 1891, and was famous as a painter of birds on china. He has published several independent volumes on the history of Shropshire, and on Clay Industries. We offer him our sincere congratulations on attaining so great an age, after a long and conspicuously useful career.

Geological Survey of India.—We have just received information that three posts of 'Assistant Superintendent' (rank) in the Geological Survey of India are open to candidates. They must have a first-class, all-round knowledge of geology, and a good general education; age not to exceed 25 years. The officers selected will be required to leave for India at about the end of the present year. Further particulars may be obtained from the Secretary, Revenue Department, India Office, London, S.W.

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OR

Monthly Journal of Geology.

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THE GEOLOGIST.

NOVEMBER, 1910.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VII.

No. XI.—NOVEMBER, 1910.

ORIGINAL ARTICLES.

I.—Notes on new or imperfectly known Chalk Polyzoa.

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

(PLATE XXXVI.)

(*Continued from the September Number, p.* 392.)

Steginopora denticulata, nov. Pl. XXXVI, Figs. 1–3.

Zoarium always unilaminate, nearly always adherent.

Zoœcia broad, length ·65–·8 mm., breadth ·45–·55 mm., aperture primarily semicircular but tending to quadrangular by thickening of the upper lip, and with a semicircular collar, the two ends of which are expanded into large perforated spine bases: the arched front wall springs from the inside of the side walls and is pierced along its edge by a row of large pores, and at a short distance inside this row by a row of smaller pores in fairly close correspondence with the outer row; the centre of the front wall is pierced by a very variable number of fine pores, which sometimes give clear indications of a third row corresponding to the two outer ones; the zoœcia always have common side walls of considerable width; in immature stages (Fig. 1) the front walls rise high above the side walls, and small beak-shaped avicularia are scattered irregularly between them; in a further stage of development (Fig. 2) the side walls are greatly thickened and raised above the front walls, absorbing the avicularia, and the perforated spine bases at the corners of the aperture grow inwards until they meet, and are fused into a stout bar across the aperture, so qualifying the species for admission to the Steginoporidæ; in the stage of maximum development (Fig. 3) the bar develops a stout denticle in the middle of the lower edge.

Oœcia not observed.

Rare in the zone of *M. cor-anguinum* at Gravesend, Broadstairs, Kingsgate Bay, and Leaves Green, near Bromley.

Steginopora Gravensis, nov. Pl. XXXVI, Figs. 4–5.

Zoarium unilaminate, adherent.

Zoœcia long and narrow, average length ·65 mm., breadth ·35–·4 mm.; with very broad common side walls, between which is deeply sunk the flat front wall pierced by numerous transverse paired slits, which only begin to radiate quite close to the foot of the zoarium, and are so fine as to be rarely well visible; aperture semi-oval, with a tiny denticle in the middle of the lower lip and a thick raised upper lip often bearing three or four perforated tubercles; the corners of the aperture are overhung by two stout perforated spine bases projecting from the upper lip, which often fill up and unite to form an arch across the lower part of the aperture; small perforated tubercles are scattered irregularly and sparingly on the side walls; these features are often very feebly marked.

Oœcia not observed.

Avicularia may be represented by the perforated tubercles.

Very rare in the zone of *M. cor-anguinum* at Gravesend.

It will be observed that the two foregoing species represent a very early stage in the evolution of the Steginoporidæ; it is curious that no species of this family is yet known to occur at any later horizon in the English Chalk.

MEMBRANIPORELLA FALLAX, nov. Pl. XXXVI, Figs. 6–8.

Zoarium unilaminate, adherent.

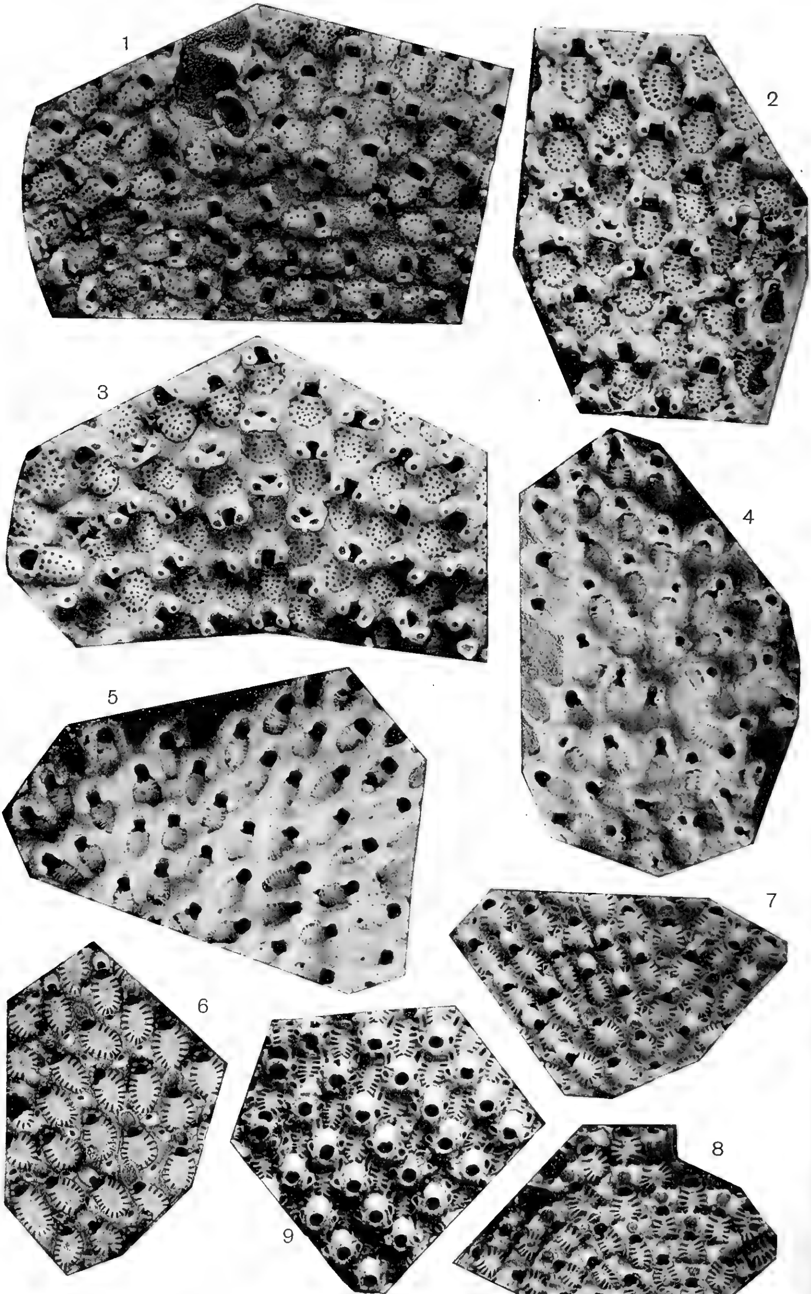
Zoœcia oval, average length ·7–·8 mm., breadth ·35–·4 mm.; the arched front wall rests on the side walls, and is pierced by seven or eight paired diverging slits extending from the edge about half-way toward the middle line: aperture semicircular, showing in ordinary specimens (Fig. 6) two imperforate tubercles on either side when there is no oœcium, the upper pair of which are picked up by and form the starting-point of the oœcium when one is formed, as is usually the case; the lower lip of the aperture often bears a median denticle of very variable size. Such specimens give a delusive appearance of organization similar to that of *Cribrilina furcifera*, but in the upper right-hand corner of Fig. 7 there may be observed a zoœcium which shows that what appear to be a pair (the lower pair) of tubercles and a median denticle are in fact the scanty remains of the true lower lip of the aperture, which has almost invariably been broken away: in another zoœcium in the same figure it is preserved on one side only.

Oœcia long and narrow, very generally present; they often appear to throw out a sort of causeway leading on to the front wall of the zoœcium (if any) immediately succeeding the same line.

Avicularia beak-shaped, small, but very deep, with a slender bar, which is rarely preserved, across the aperture; generally lying more or less on their sides and with a strong tendency to occur singly or in pairs with their beaks directed downwards or inwards at the head of the zoœcium. Fig. 8 shows a specimen of exceptional regularity in this respect.

The species is not uncommon in the zone of *M. cor-anguinum* at Gravesend, and a dwarfed form has been found at the top of the zone of *Marsupites* at two places in Hants. It comes nearest to the form figured by Novak [1] as *Lepralia pediculus*, Rss., but is easily

[1] Novak, Denkschr. d. k.k. Ak. d. Wiss. zu Wien, Math.-Naturw. Cl., Bd. xxxvii, p. 93, pl. i, fig. 12.



R. M. Brydone, Photo. *Bemrose, Collo.*

CHALK POLYZOA.

distinguished from it and still more easily distinguished from Reuss' original figure.[1]

MEMBRANIPORELLA PUSTULOSA, nov. Pl. XXXVI, Fig. 9.

Zoarium unilaminate, adherent.

Zoœcia long and slender, average length ·7–·8 mm., breadth ·3–·4 mm.; the aperture is enclosed by a raised ring which is either truly circular or slightly broader than long, and merges in the upper part with the oœcium, much as in *M. castrum*; the side walls are thin, exsert, and quite separate from those of the adjoining zoœcia; the front walls are formed by a broad backbone united to the side walls by about seven ribs springing from the inside of the side walls and with well-marked and sometimes considerable spaces between them.

Oœcia globose, without external aperture, and cutting into the front wall of the succeeding zoœcium; they are almost invariably present.

Avicularia mandibular, thin-walled, small but wide; in normal zoœcia there is always one on either side of the aperture with the beak pointing downwards, and others occur irregularly along the side walls.

Occurs in all zones from that of *M. cor-anguinum* to that of *B. mucronata.*

This species is closely related to *Cellepora galeata*, Hag.,[2] in which species, however, the apertural ring is distinctly longer than broad, the spaces between the ribs are very short and do not reach the side walls, there is only a very slight swelling to suggest an oœcium, and the side walls are broad and common.

EXPLANATION OF PLATE XXXVI.

(All figures × 12 diams.)

FIG. 1. *Steginopora denticulata.* Gravesend.
,, 2. Ditto. Broadstairs.
,, 3. Ditto. Gravesend (another specimen).
,, 4. *Steginopora Gravensis.* Gravesend.
,, 5. Ditto. Gravesend (another specimen).
,, 6. *Membraniporella fallax.* Gravesend.
,, 7. Ditto. Gravesend (another specimen).
,, 8. Ditto. West Tisted, Hants. A dwarfed form.
,, 9. *Membraniporella pustulosa.* Gravesend.

II.—A FRAGMENT OF A FOSSIL IN A CHALK FLINT PEBBLE FROM THE SHERRINGHAM BEACH, NORFOLK.

By HENRY WOODWARD, LL.D., F.R.S.

THE difficulties which the palæontologist encounters in attempting the interpretation of fossil organic remains are numerous, especially when compared with the task of the zoologist in the study of recent forms. In a fossil, for instance, the soft parts of the animal are wanting, while the endo- or exoskeleton is often remarkably

[1] *Das Elbthalgebirge in Sachsen*, pt. ii, p. 129, pl. xxiv, fig. 16.
[2] In Geinitz, *Grundriss d. Versteinerungskunde*, p. 613, pl. xxiii *b*, fig. 34.

dissimilar from that of its nearest living allies. Furthermore, the object he has to deal with has undergone mineralization, more or less completely, so that its appearance is greatly altered. But most frequently the object placed before him is only a fragment of the hard part of some animal which he is nevertheless called upon to identify at once.

Here is a case in point: my friend Mr. W. H. Paterson requested me to name a fragmentary fossil embedded in a waterworn flint from the Chalk, picked up by Mrs. Paterson some years since on the beach at Sherringham, Norfolk. The structure (whatever it might be) occupied only a part of the pebble (Fig. 1), and was also partially exposed on the reverse side (Fig. 2). It was certainly not related to the ordinary forms of inorganic markings known as 'banded flints', which frequently occur as flint pebbles on our shores, and were at one time believed by Dr. Bowerbank and others to be the remains of fossil sponges. My brother, the late Dr. S. P. Woodward, described a number of these in a paper in the GEOLOGICAL MAGAZINE (1864, Vol. I, pp. 145–9, Plates VII and VIII). The banded structure in

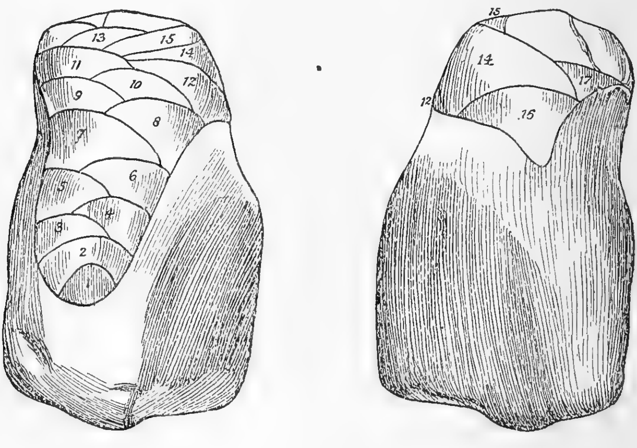


FIG. 1. FIG. 2.

FIG. 1, obverse; FIG. 2, reverse side of waterworn flint pebble from the beach at Sherringham, Norfolk. In the collection of W. H. Paterson, Esq.

these flints is certainly due in many cases to deposition (op. cit., Pl. VI, Fig. 4), but in other instances the banding, if not caused by, is accentuated by the introduction within the flints of mineral colouring matter, carried in solution by water permeating the flint along lines of least resistance; for even flint contains much water interstitially within its pores, which escapes by evaporation when flints lie exposed upon the surface. Instead of the transverse lines seen in ordinary banded flints, the surface of the Sherringham pebble displays about fifteen imbricated, scale-like markings upon its front or obverse (Fig. 1) side, and two or three additional ones (evidently part of the same structure exposed on the reverse side) near the top end of the flint (Fig. 2). I assume, for description, that the convex edge of the scale-like markings is the *upper margin* as shown in the drawing.

Measurement of scales from exposed base to summit.

From base, scale No.	1 is	8 mm.	broad	by	5 mm.	high.
	2	15	,,	,,	5	,,
	3	12	,,	,,	5	,,
	4	14	,,	,,	7	,,
	5	13	,,	,,	13	,,
	6	16	,,	,,	7	,,
	7	23	,,	,,	9	,,
	8	17	,,	,,	8	,,
	9	15	,,	,,	5	,,
	10	15	,,	,,	5	,,
	11	17	,,	,,	5	,,
	12	17	,,	,,	4	,,
	13	20	,,	,,	5	,,
	14	43	,,	,,	10	,,
To summit	15	18	,,	,,	4	,,

Scales on reverse side exposed near the summit of the flint.

Nos. 12 and 14 both wrap around the edge of the flint, and appear on the reverse side also, intercalated with Nos. 16 and 17.

No. 16 is	20 mm.	broad	by	10 mm.	high.
17	10	,,	,,	5	,,

The upper portion is obscured, being, like the rest of the pebble, much worn down by rolling and attrition. The lower part of the pebble is composed of a dark amorphous flint which merges into a lighter shade near the scale-like markings.

If we compare the specimen before us with the rare remains of Coniferous cones met with in a fossil state, I cannot remember to have seen a silicified Cretaceous example, nor one in which the carbonaceous matter was not preserved and showed the separate bracts visibly overlapping one another from the apex to the base. This is not the case in the fossil in flint we are considering.

I suggested to Dr. Arthur Smith Woodward that possibly the specimen might represent a fragment of a fossil fish, but he pointed out to me that the scale-like markings are not uniform, nor are they arranged symmetrically, also that they have been worn away to one level, and have no structure visible.

I compared the pebble with a fish-coprolite from the Chalk, but although these bodies have an arrangement in layers the phosphatic material composing them is always preserved, and they have never in my experience been met with silicified or enclosed in a chalk flint.

I submitted the rolled flint to Dr. F. A. Bather, but after a careful examination he wrote on the label the following note: "No one in the Geological Department considers the markings organic. The bands have no appreciable thickness. (F. A. B.)"

I wrote to my friend Dr. Hinde to ask whether the specimen might possibly be attributable to a fossil sponge, chalk sponges being most abundantly met with in that formation enclosed in flints. He replied that the markings did not resemble those of any sponge with which he was acquainted.

I then placed the specimen before me and meditated upon it from time to time, a process which I have frequently found tended to illumination. I recalled the well-known fact that there are quite a number of corals and mollusca which build up body-chambers needlessly large for their personal accommodation, and then proceed to reduce them again by shutting off a portion from time to time by secreting a shelly partition or septum across the lower part of the living-chamber.[1] Such energy in shell-growth has been attributed to various causes:—(1) There may be a necessity for the animal to grow upwards to prevent its being immersed in sand or other sediment which threatened to overwhelm the sedentary mollusc or coral. (2) Professor H. G. Seeley suggested that more rapid shell-growth in Cephalopod shells was due to a periodic necessity to provide a larger body-chamber to accommodate the gravid ovisacs of the female prior to the extrusion of the ova. (3) Professor Owen suggested that the mantle of the mollusc, which secretes the shell, deposited new matter to its outer border more rapidly than it does to the umbonal or hinge-area.

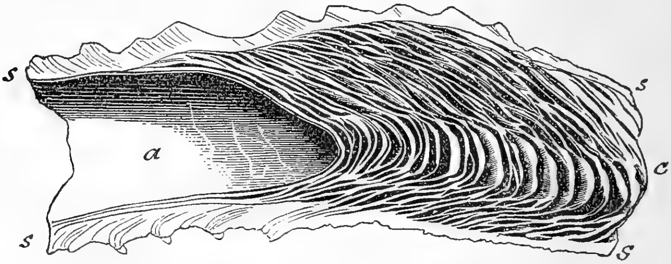


FIG. 3. Section of a portion of the shell of a long-beaked oyster, *Ostrea cornucopiæ*, showing interior (umbonal) portion of valve filled up by a series of extremely thin lamellæ (*c*), quite distinct from the compact shell-wall (*s*, *s*); *a*, part of the body-chamber occupied by the animal. (From Dr. S. P. Woodward's *Manual of the Mollusca*, 1851–6, 1st ed., p. 281, fig. 192.)

This addition to the margin of the shell compels the animal to advance its body and the attachment of its shell-muscles also, in order to follow this forward or upward growth of the shell. To obviate the excess of space thus acquired the lining-mantle of the animal partitions off the lower portion of its body-chamber by secreting a series of shelly layers, very regular in Cephalopod shells, such as the Nautilus and Ammonite, but more or less irregular in the other Mollusca, such as the Water Spondylus, the Exogyra, and some Hippurites and Oysters. (Fig. 3.)

[1] See a series of illustrated articles "On the Form, Growth, and Construction of Shells" by the late Dr. S. P. Woodward, edited by H. Woodward, in the *Intellectual Observer*, vol. x, pp. 241–53, November, 1866; vol. xi, pp. 18–30, 161–72, 1867. See also Henry Woodward, "The Pearly Nautilus, Cuttle-fish, and their Allies": *Student and Intellectual Observer*, vol. iv, pp. 1–14; pt. ii, pp. 241–9, 1870. "On the Structure of the Shell of the Pearly Nautilus," 1870, Brit. Assoc. Sect., Liverpool Meeting, p. 128. "On the Structure of Camerated Shells": *Popular Science Review*, vol. xi, pp. 113–20, pl. lxxxii, 1872.

In some corals the lower portion of the corallite chamber may be shut off by nearly regular simple horizontal septa, as in *Favosites*, or the interior may be filled by irregularly formed meniscus-like cells filling up the central cavity below each polype, as seen in the Zoantharia Rugosa. In *Ostrea cornucopiæ* (Fig. 3), and in a species of oyster from the Tertiary of Cerigo, Ionian Isles, in Mr. W. J. Hamilton's Collection (Brit. Mus. 34033), a large portion of the interior of the shell is shut off by numerous irregular septa forming, as in *Spondylus*, water-cavities within the shell. These inner septal shell-layers are *quite distinct* from the *outer shell-wall*, they are much less compact, the lamellæ are extremely thin, and they are often dissolved out entirely in the fossil forms.

In those singular molluscs the Rudistes we have forms like *Hippurites organisans*, Montf., in which a portion of the lower deep valve is partitioned off, like an *Orthoceras*, by a succession of almost regular septa, the intervening spaces forming water-chambers (Zittel, *Palæont.*, p. 282, fig. 632, 1895).

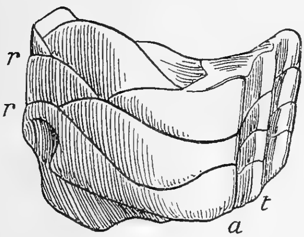


FIG. 4.

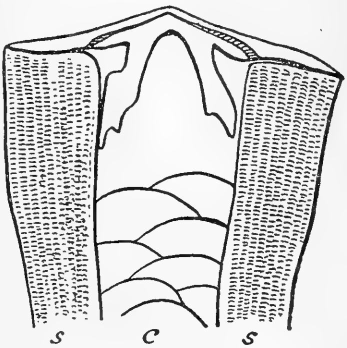


FIG. 5.

FIG. 4. Part of the internal *mould* taken from the interior of a shell of *Radiolites Mortoni*, Mantell (reduced), representing some of the water-chambers of the original shell, perforated by cliona. *r*, *r*, joints produced by the decomposition of the septa; *a*, furrows produced by adductor ridges; *t*, furrows produced by the dental ridges. From S. P. Woodward's article in Q.J.G.S., vol. xi, pl. v, fig. 2, 1855.

FIG. 5. Diagrammatic vertical section through shell of *Radiolites*, showing *s*, *s*, the outer shell-wall composed of prismatic cellular structure, the prisms being vertical to the shell-laminæ and minutely subdivided. *c*, section of the inner layer composed of transverse lamellæ, which are extremely thin, and are separated by intervals, like the water-chambers of *Spondylus*, and the similar spaces in the umbonal cavity of the long-beaked oysters. (See Fig. 3 *supra*; compare also with Fig. 1.)

In the British Cretaceous species *Sphærulites* (*Radiolites*) *Mortoni* the outer shell-wall is very thick and consists of dense prismatic cellular structure, like the recent *Pinna*. The lower central part of the valve has been shut off from time to time by a series of somewhat irregular meniscus-like septa, deposited by the mantle and built up in succession one upon another. In a specimen described by

Dr. S. P. Woodward in his classical paper "On the Structure and Affinities of the Hippuritidæ" (Quart. Journ. Geol. Soc., vol. xi, pp. 40–61, pl. v, figs. 1, 2, 1855), and preserved in the British Museum (Nat. Hist., No. 38219), obtained from the *Micraster cor-anguinum* zone of the Chalk at Rosherville, Gravesend, the internal chambers have been filled up solid and the extremely thin, shelly septa afterwards dissolved away, leaving only an internal mould composed of very hard chalk representing some of the chambers of the original shell (see Fig. 4). The shelly septa, always very thin and fragile, are commonly entirely dissolved out, or, as in this instance, replaced by a mould of chalk or flint, the shells of many *Radiolites* being more or less converted into or embedded in flint, as is also the case with the shells of *Inoceramus* from the Chalk.

Here, then, I think we have succeeded in finding a solution for the exceedingly puzzling rolled fossil in flint from the Sherringham Beach, and I feel justified in considering it to be the waterworn fragment of the chambered portion of the shell of a Radiolite, and most probably of *R. Mortoni*, replaced by silica. The outer prismatic cellular shell-wall in which this chambered portion was originally enclosed (see Fig. 5) has entirely disappeared, and the only evidence left is a relic of the mould in flint, of the chambers of which we see only the thin edges as they pass inwards to form in succession the series of transverse floors of what had been at one time a part of the body-chamber of the animal.

III.—The Residual Earths of British Guiana commonly termed 'Laterite'.

By Professor J. B. Harrison, C.M.G., M.A., F.G.S., F.I.C., assisted by K. D. Reid, Assistant Analyst British Guiana.

(*Continued from the October Number, p.* 452.)

The Christianburg and Akyma deposits afford excellent examples of the highly aluminous or bauxitic type of laterite formation. They here occur as parts of a residuary deposit derived from the decomposition in situ of an igneous rock, probably a porphyrite or a tuff, an almost pure quartz-sand, and masses of bauxite containing in the more aluminous varieties from 92·6 to 94·4 per cent. of the hydrates of alumina and in the ferruginous ones 64·6 per cent. of the hydrates of alumina with about 24 per cent. of the oxides and hydrates of iron.

The Christianburg and Akyma deposits illustrate excellently 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. No explanation of the extreme intensity of the lateritic action in the Christianburg–Akyma district is at present obtainable. But as it is proposed to work the deposits I may be able to obtain further information when clean sections of them are available.

The foregoing examples represent the types of the residual deposits in situ in British Guiana, which I have regarded as and termed laterite. The concretionary masses in various parts of them range from ironstones with in round figures 93 per cent. of iron-ores and with less than 2 per cent. of aluminium hydrate to bauxites with less than 2 per cent. of iron-ores and with over 94 per cent. of aluminium hydrate. But the main bulk of the residual deposits in situ correspond to those which G. C. Du Bois in his monograph termed "Eluviale Laterite (primäre Laterite)", or "Kieselsäurereiche Laterite".

They are essentially buff, ochreous, red-brown or chocolate-coloured, ferruginous, more or less siliceous, clays and earths; and consist of mixtures in various proportion of angular quartz-sand and siliceous grit derived in part from quartz originally present in the rock of which they are products and in part secondarily from the decomposition of the felspars; of kaolinite, of bauxite, and of limonite, or other more or less hydrated oxides of iron, derived from the decomposition, hydration, and oxidation of the constituents of the felspars and of the ferro-magnesian minerals.

The mean proximate composition of the British Guiana lateritic earths which I have examined is in round figures:—

Table X.

Quartz	24
Iron-ores (including pisolites)	32
Kaolin, Sericite, and other felspathic debris, etc.	24
Bauxite	20
	100

The earths I quoted as examples of the lateritic earths in my work on the Geology of the Gold-fields of British Guiana by weathering, detrition, washing, and re-arrangement of their proximate constituents could give rise to deposits consisting mainly of quartz-sand and of more or less bauxitic masses. For instance, the Tumatumari earths, if separated by natural elutriation, would give rise to a quartz-sand, say with 90 per cent. of quartz, and to bauxite with 63 per cent. of aluminium hydrate and 20 per cent. of iron-ores.

Whilst in the examples discussed there is no difficulty in tracing the silica set free during the decomposition of the rock into the form of masses of quartz as at Issorora, or into that of quartz-sand as in the earths from Tumatumari, Omai, Mazaruni, and Christianburg–Akyma, there are other cases in which little of the silica remains through the mass of the laterite. In some of these the ferruginous or aluminous lateritic earths are traversed by numerous thin veins of secondary quartz which intersect one another in all directions. These quartz-veins, which towards the surface of the laterite are not infrequently auriferous to paying extents or to even well-marked degrees, lessen in their contents of gold and tend to become barren when followed to a depth where they gradually thin completely out before reaching the less altered layers which are just above the undecomposed rock. In other places, as I have described elsewhere, the silica has segregated out in the form of lenticular masses not uncommonly described as 'quartz-reefs'.

Among places where the origin of the auriferous veins and masses of secondary quartz which occur in the laterite of the Guianas has been discussed, I may mention p. 41 of *Guide Pratique pour la recherche et l'exploitation de l'or en Guyane Française* by M. E. D. Levat (1898), pp. 21 and 22 of G. C. Du Bois' above quoted work on the Surinam laterite (1903), pp. 11 and 12 of the *Geology of the North-Western District of British Guiana* by H. I. Perkins and myself (1897), pp. 208 and 209 of the *Geology of the Gold-fields of British Guiana* (1908), and pp. 28 and 29 of *Goudindustrie in Suriname* by E. Middelberg (1908).

The attention of the technical geologists and the mining experts who have personally studied on the spot the residuary lateritic formations of the Guianas has necessarily been more attracted to the occurrence and nature of the secondary veins of auriferous quartz and to the gold disseminated in them than to the, from their point of view, very subordinate question of the presence or not of free aluminium hydroxide in the earths.

Decomposed Granites, Kaolins, or Pipe-clays.—The following are analyses of a granite and of a hornblende granitite, and of the products of their decomposition by weathering in situ, and of similar products of a granite, and of an aplite of which the compositions are not known:—

TABLE XI.

	Mazaruni.		Mahdia.		San San Kopai.	Orealla.
	Mazaruni River.		Potaro River.		Upper Mazaruni River.	Couranlyne River.
	Granite.	Pipe-clay	Hornblende Granitite.	Pipe-clay	Pipe-clay from Granitite.	Pipe-clay from Aplite.
Quartz	36·60	38·70	29·50	38·15	48·32	6·69
Colloid Silica		1·60		·43	1·40	3·75
Combined Silica	37·21	27·68	38·70	25·25	23·08	42·44
Aluminium Oxide	13·93	19·82	15·83	24·60	17·67	33·02
Iron Peroxide	0·93	2·05	2·86	2·67	1·56	1·36
Iron Protoxide	0·46		0·51			
Magnesium Oxide	0·72	·11	2·14	·39	·22	·61
Calcium Oxide	0·88	nil	3·49	·10	·07	·02
Sodium Oxide	2·80	·39	3·07	nil	·36	·52
Potassium Oxide	4·81	·50	2·88	·41	·33	·17
Water	0·74	8·52	0·50	6·92	6·20	11·35
Titanium Oxide	0·62	·85	0·46	1·01	1	·01
Phosphoric Anhydride	0·06	·01	0·01	nil		nil
Manganese Oxide	0·24	trace	0·08	nil	trace	nil
	100	100·23	100·03	99·93	100·21	99·94

Their mineralogical compositions are shown as follows:—

TABLE XII.

	Mazaruni.		Mahdia.		San San Kopai.	Orealla.
	Mazaruni River.		Potaro River.		Upper Mazaruni River.	Couranlyne River.
	Granite.	Pipe-clay	Hornblende Granite.	Pipe-clay	Pipe-clay from Granite.	Pipe-clay from Aplite.
Quartz	36·6	38·7	29·5	38·1	48·3	6·7
Colloid Silica		1·6		·4	1·4	3·8
Orthoclase	20·6	2·9	15·5	2·4	1·9	1
Plagioclase	27·1	3·4	37·5	·5	3·4	4·6
Mica	13·3		3·3			
Hornblende			12·7			
Magnetite	1·1					
Limonite		·8		1·8	·8	1·6
Ilmenite	·3	1·6		1·9	1·9	·02
Sphene	1·2		1·2			
Kaolinite		50·2		48·6	42	80·4
Talc		·3		1·2	·7	2
*†Bauxite		nil		4·9	nil	·2
Minor constituents		·5	·3	·2		
	100·2	100	100	100	100·4	100·32
*Diaspore				1·4		
Gibbsite				3·5		·2
†Total Alumina present in Bauxite		nil		4·6	nil	·1

These products of granites decomposed in situ may be termed either decomposed granites, kaolins, or pipe-clays. They are white or creamy-white, soft, earthy rocks which do not harden on exposure to the atmosphere, but gradually crumble down when wetted by rain. They are mixtures of varying proportions of sharply angular quartz-sand and of clay-substance (kaolinite with a little finely divided felspathic rock powder, or flour), with usually small proportions of colloid silica, either without or with aluminium hydrate in more or less negligible proportions, with a little ilmenite and with very small proportions of limonite.

Another type of the residual products of the alteration, probably largely by deep-seated hydro-metamorphism of pegmatites and aplitic granites, is the sericitic one. This type is at times erroneously regarded as produced by ordinary processes of weathering. The rocks are glistening white, exceedingly soft, silky-feeling masses, which do not harden on exposure to the air, but quickly disintegrate to a sandy powder when moistened by rain or when placed in water. Their chemical compositions, their physical properties, and the microscopical examinations of them show that sericite is present in them to a considerable extent. The chemical compositions of two typical specimens are as follows:—

TABLE XIII.

	Minnehaha, Potaro District.	Mindrinetti, Surinam.
Quartz	23·23	20·30
Colloid Silica	·40	·38
Combined Silica	32	26·28
Aluminium Oxide	31·49	34·10
Iron Peroxide	·68	6·56
Magnesium Oxide	·21	·27
Calcium Oxide	·10	·02
Sodium Oxide	·25	·39
Potassium Oxide	1·25	1·97
Water	9·67	8·43
Titanium Oxide	·67	1
Phosphoric Anhydride	nil	nil
Manganese Oxide	nil	nil
	99·95	99·70

Their proximate mineralogical compositions appear to be—

TABLE XIV.

	Minnehaha, Potaro District.	Mindrinetti, Surinam.
Quartz	23·2	20·3
Colloid Silica	·4	·4
Sericite	14·3	21·6
Kaolinite	53·9	34·0
Talc	·7	·9
*†Bauxite	6·0	15·0
Ilmenite	1·3	2·0
Hæmatite		5·5
Minor constituents	·2	·3
	100	100
*Diaspore	3·1	12·8
Gibbsite	2·9	2·2
†Total Alumina present in Bauxite	4·6	12·3

These earths are mixtures of fine, sharply angular quartz-sand, kaolinite, and sericite, with lesser proportions of bauxite, the latter being present to the extent of 6 per cent. in the Minnehaha sample and to 15 per cent. in the one from Surinam. The principal differences between the Mindrinetti sample and the Omai sericitic laterites already described are in the higher proportion of limonite present in the latter and in the higher state of hydration of its bauxite. The more highly hydrated rock shows the setting power of true laterite; the rock of lower hydration does not in any way exhibit it.

Both these sericitic earths are more or less auriferous, and have been worked for gold.

Neither the pipe-clays, the products of the decomposition of granites, pegmatites, more or less aplitic granitite, and aplite in situ, nor the sericitic earths, their alteration products, have any claim to be termed laterite, as they neither indurate on exposure to the atmosphere nor do they consist mainly or even to any extent of the hydrates of alumina.

Rocks other than highly aluminous ones showing to marked degrees the characteristic property of Buchanan's Laterite.—The gradual setting or hardening on exposure to the atmosphere of residual masses is not a characteristic only of either purely ferruginous, partly ferruginous and partly aluminous, or purely aluminous deposits. It may characterize to even a more marked degree other residuary deposits from igneous rocks. As an instance I may mention a mottled, creamy-white, and dark-red deposit which occurs in a low cliff at Kongkamo near the Ireng River in the territory recently assigned to Brazil. This is a clay-like mass which when first dug is quite soft and can be cut like cheese by an iron knife.[1] Upon exposure to the air the mass indurates gradually until the creamy-white parts attain a hardness of from 3·5 to nearly 4 of Mohs' scale, the dark-red parts becoming still harder. The composition of this material is shown by the following analysis:—

TABLE XV.

Quartz	·94
Colloid Silica	·58
Combined Silica	43·82
Aluminium Oxide	35·49
Iron Peroxide	4·40
Magnesium Oxide	·41
Calcium Oxide	·12
Sodium Oxide	·63
Potassium Oxide	7·53
Water	5·23
Titanium Oxide	·60
Phosphoric Anhydride	trace
Manganese Oxide	nil
	99·75

This corresponds to the following mineralogical composition:—

TABLE XVI.

Quartz	1
Colloid Silica	·6
Orthoclase	44·4
Plagioclase	5·9
Kaolinite	22·1
Talc	1·3
*†Bauxite	19·5
Ilmenite	1·2
Hæmatite	3·8
Minor constituents	·2
	100
*Diaspore	14·2
Gibbsite	5·3
†Total Alumina present in Bauxite	17·4

Microscopic examinations show that it is not like the ferruginous and aluminous masses of the lateritic earths, an infiltrated or

[1] It is thus used by the aboriginal Indians in making images and other carved ornaments.

a concretionary mass, but that it is made up of exceedingly fine felspathic rock powder, a few particles of which show the characteristics of plagioclase, with varying proportions of kaolinite, bauxite, and oxide of iron. Although it cannot be described as 'laterite' when judged on the lines laid down by Mr. Crook, its properties closely resemble the characteristic ones ascribed to that substance by Buchanan, and on account of which he proposed for it the name 'laterite'.

Oolitic 'Laterite'.—Du Bois, in his monograph on the laterites of Surinam, showed as figs. 2, 3, and 6 of pl. i two varieties of the components of Surinam laterite which he termed respectively "pisolithischen Eisenerzkonkretionem" and "oolithartigen Beauxit". I have obtained specimens closely resembling in general appearance these types—a red ferruginous one from near Arawak Matope on the Cuyuni River and a white one from the Berbice River. The specimen from the Cuyuni River consists of spheroids filled with dark-red ochre surrounded and cemented together by a white cementing material having a concretionary structure. It is an aggregate of ironstone pisolites cemented into a mass. That from the Berbice River consists of white and yellowish-white and of a few reddish spheroids cemented together by a white material in a similar manner to the Cuyuni specimen. When first obtained the specimens were quite soft, and could be very easily cut with a knife, the spheroids being the harder parts of them. The cementing material has gradually hardened, and now the rocks are somewhat harder than are any of the specimens of purely ferruginous or aluminous concretionary laterite I have described in this paper. The cementing material is now the hardest part of the specimens, the innermost part of the spheroids the softest. From their very marked properties of induration on exposure to the atmosphere these rocks appear to have a well-founded claim to the term 'laterite' as used by Buchanan. But they are not laterite in the sense of being mainly aluminous in composition, the restriction which has recently been superimposed on Buchanan's original description of laterite. This is clearly shown by the chemical and proximate mineralogical compositions detailed in the following analyses:—

Table XVII.

	Matope, Cuyuni (red).	Berbice (white).
Quartz	·06	6·79
Colloid Silica	·40	·33
Combined Silica	24·07	36·92
Aluminium Oxide	21·42	34·82
Iron Peroxide	40·80	3·85
Magnesium Oxide	·85	·16
Calcium Oxide	·17	·07
Sodium Oxide	nil	nil
Potassium Oxide	·20	·32
Water	11·41	12·74
Titanium Oxide	·95	3·85
Phosphoric Anhydride	trace	trace
Manganese Oxide	nil	nil
	100·33	99·85

TABLE XVII (*continued*).

	Matope, Cuyuni (red).	Berbice (white).
Quartz	·1	6·8
Colloid Silica	·4	·3
Orthoclase	1·2	1·9
Plagioclase	·8	·3
Kaolinite	45·5	76·3
Talc	2·7	·4
*†Bauxite	4·4	6·5
Ilmenite	1·9	7·4
Hæmatite	19	
Limonite	24·2	traces
Minor constituents		·1
	100·2	100
*Gibbsite	4·4	6·5
†Total Alumina present in Bauxite .	2·9	4·2

The cementing material of these rocks is kaolinite with varying proportions of felspathic rock powder and perhaps some bauxite. The contents of the spheroids in the red one from the Cuyuni is presumably a mixture of oxide and hydrate of iron, of which constituents the rock contains over 40 per cent. In the white one from the Berbice River both spheroids and cementing material appear to consist mainly of kaolinite with some bauxite. In their compositions the rocks offer little resemblance to those of the two varieties of purely ferruginous and purely aluminous laterite described by Du Bois which they so very closely resemble in other respects.

(*To be concluded in the December Number.*)

IV.—THE CRETACEOUS CIRRIPEDE *POLLICIPES LÆVIS*, J. DE C. SOWERBY.

By THOMAS H. WITHERS.

J. DE C. SOWERBY (1836, p. 335) founded two new species of *Pollicipes* from the Gault of Folkestone. To the one, based on a carina and tergum, he gave the name *P. lævis* (p. 335, pl. xi, fig. 5); to the other, based on a rostrum and one of the latera of the lower whorl, the name *P. unguis* (p. 335, pl. xi, fig. 5*). He also referred a carina and tergum from the Upper Greensand of Blackdown to *P. lævis* (p. 340, pl. xvi, fig. 1), but published no description of them.

J. Steenstrup (1837, p. 363) founded the species *P. elongatus* on a scutum and tergum from the Danian of Denmark, but later (1839, p. 409, pl. v, figs. 7–11, 7*) referred the type-specimens, with other valves, to Sowerby's *P. lævis*.

Subsequently, C. Darwin (1851, p. 55) maintained the species *P. elongatus*, at least for the scutum, and (p. 65) recognizing that the valves from the Gault of Folkestone described by Sowerby under the names *P. lævis* and *P. unguis* represented a single species, thought it advisable to adopt for it Sowerby's name of *P. unguis*, especially as Steenstrup (1839) had described valves belonging to different species under Sowerby's name *P. lævis*.

The valves from the Upper Greensand of Blackdown remain to be considered.

Since it cannot be ascertained that the specimens figured by Sowerby are still preserved, it is proposed to describe and figure some similar valves from the same horizon and locality, formerly in the collection of the late W. Vicary, F.G.S. They were recorded by the Rev. W. Downes, F.G.S., in List of Fossils from Blackdown (Q.J.G.S., 1882, vol. xxxviii, p. 86), and are now preserved in the British Museum (Natural History).

C. Darwin (1851, p. 80) says of the valves figured by Sowerby "... the *P. lævis* from Blackdown ... seems to be certainly a distinct species, and possibly a *Scalpellum*: no details are given". Darwin apparently did not see the actual specimens, or he would at once have recognized that they did not belong to *Scalpellum* but to *Pollicipes*. The parietes of the carina are not separated by any defined ridge or angle from the tectum as in *Scalpellum*, neither is the tergo-lateral margin of the scutum divided into two distinct lines, as is the case in *Scalpellum*, owing to the abrupt ending of the upturned lines of growth.

Since there is a general similarity in the characters of these valves, and since no other Cirripede remains have as yet been found associated with them in the Blackdown Beds, it seems safe to regard them as belonging to a single species, namely—

POLLICIPES IMBRICATUS, sp. nov. Figs. 1–3.

1836. *Pollicipes lævis*, J. de C. Sowerby, Trans. Geol. Soc., ser. II, vol. iv, p. 340, pl. xvi, fig. 1 (*non* pl. xi, fig. 5).

Diagnosis.—Valves thin, composed of a number of consecutive and slightly imbricate segments, the lines of junction being marked on their external and inner surfaces by shallow obtusely V-shaped grooves. Scutum trapezoidal in outline; apex blunt; occludent portion twice as wide as the tergo-lateral portion; basal margin nearly at right angles to the occludent margin, and to the lower part of the tergo-lateral margin; there is no deep pit on the inner surface for the adductor scutorum muscle. Carina triangular in transverse section, with basal margin angular (about 92°).

Material.—A nearly perfect carina on a hard shelly matrix (B.M., I. 5392). A portion of a carina (B.M., I. 13518), portions of two scuta (B.M., I. 13519, I. 13520), and portions of two terga (B.M., I. 13521, I. 13522); all these are free from matrix. The whole of the material is silicified.

Holotype.—The right scutum (Figs. 1*a*, *b*).

Horizon and Locality.—Albian, Upper Greensand: Blackdown, Devonshire.

Description of Specimens.—Right scutum (Figs. 1*a*, *b*; B.M., I. 13519) convex, valve thin, divided unequally by a ridge extending from the apex to the basi-lateral angle; occludent margin slightly convex; basal margin nearly straight; basi-lateral angle blunt; tergo-lateral margin convex, and protuberant near the middle. The unequally-spaced surface-grooves, which represent the growth periods, are very slightly sinuous on the occludent portion; on the tergo-lateral portion they are sharply upturned, and on nearing the margin curve inwards towards the apex. Occludent margin (from apex to rostral angle) 7·5 mm., tergo-lateral margin (from apex to basi-lateral angle) 8 mm., basal margin 5 mm.

Left tergum (Fig. 2; B.M., I. 13521) sub-rhomboidal, slightly convex; a rounded ridge, steep on the carinal side, divides the valve into two unequal portions; the carinal portion is somewhat depressed and in its widest portion is about two-thirds the width of the occludent portion; the occludent portion is again divided almost equally by an obscure ridge from the apex to the scutal margin, which is immediately followed by a wide groove, almost parallel to the occludent margin. The well-marked grooves, of which there are seven on the portion preserved, are straight on the carinal portion, and on the occludent portion are straight until they reach the inner edge of the wide groove, and thence are recurved until they reach the occludent margin, where they are more sharply curved towards the apex.

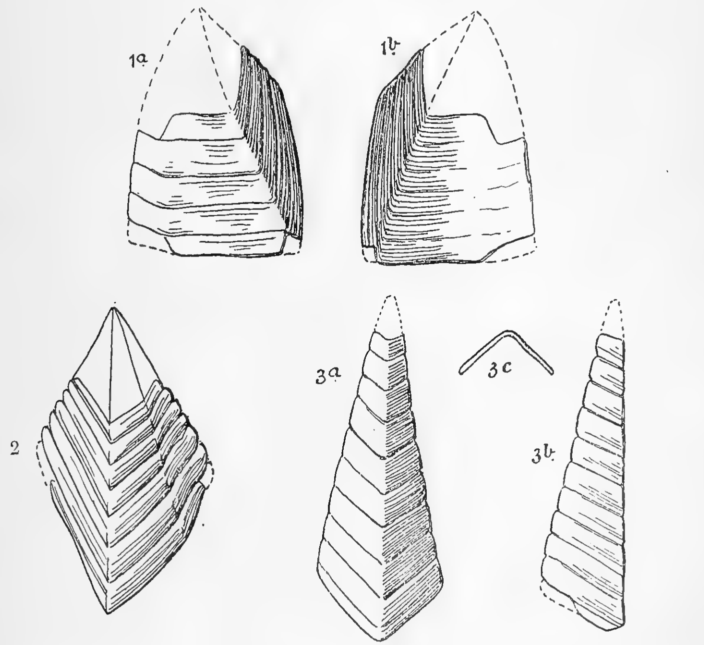


Fig.
1*a*. *Pollicipes imbricatus*, Withers, sp. nov. External view of right scutum. Albian, Upper Greensand: Blackdown, Devonshire. B.M., I. 13519.
1*b*. Id. Inner surface of same.
2. Id. External view of left tergum. B.M., I. 13521.
3*a*. Id. External view of carina. B.M., I. 5392.
3*b*. Id. Side view of same.
3*c*. Id. Transverse section of same at one-third from base. All figures × 4 diam.

Length 9 mm., greatest breadth 6 mm., length of occludent margin 5·5 mm., length of scutal margin 6·5 mm.

Carina (Figs. 3*a–c*; B.M., I. 5392) almost straight, with thin walls, widening gradually from the apex, subcarinated, triangular in transverse section, about twice as wide as high; apex probably pointed; basal margin angular (about 92°). The only ornamentation is the well-marked grooves, of which there are eleven on the portion preserved.

Length 10·5 mm., greatest breadth 3·5 mm.

Measurements.—As all the valves are slightly broken, it is impossible to give accurate measurements, but those given probably err very little. The broken parts are indicated in the figures.

Comparison with other Species.—The scutum of *Pollicipes imbricatus* agrees with that of *P. elongatus*, J. Steenstrup (1837), from the Upper Chalk (Danian) of Denmark, in its general outline, and in having the wide, regularly spaced, well-marked grooves about the same distance apart as the growth-lines of *P. elongatus*. It is distinguished from *P. elongatus*, among other characters, in the occludent portion of the valve being twice the width of the tergo-lateral portion. In *P. elongatus* the occludent and the tergo-lateral portions are the same width. The tergum of *P. imbricatus* is altogether different from that valve referred to *P. elongatus*, and therefore need not be discussed. The carina and tergum of *P. imbricatus* were considered by J. de C. Sowerby (1836, p. 340) to belong to his *P. lævis* = *P. unguis*. The carina disagrees with that of *P. unguis* in being much narrower, straighter, more angular in transverse section, and in the presence of the well-marked grooves, which make a much more acute angle than do the growth-lines in *P. unguis*. The tergum of *P. imbricatus* differs from that of *P. unguis* mainly in having a much wider groove running parallel to the occludent margin, and about half the width of the occludent portion of the valve. The scutum of *P. unguis* differs in the general outline of the valve, which approaches an equilateral triangle, and consequently the apex is much more acute than in *P. imbricatus*. The scutum of *P. unguis* is also much thicker, and has a deep pit for the adductor scutorum.

There is little doubt that *P. imbricatus* is closely allied to *P. unguis*, J. de C. Sowerby, and *P. glaber*, F. A. Roemer (1841, p. 104, pl. xvi, fig. 11).

The scutum of *P. imbricatus* is distinguished from all other scuta that I have seen, either of *Pollicipes* or *Scalpellum*, by the entire absence of any pit or depression for the adductor scutorum.

Pollicipes unguis, J. de C. Sowerby. Figs. 4, 5.

1836. *Pollicipes unguis*, J. de C. Sowerby, Trans. Geol. Soc., ser. ii, vol. iv, p. 335, pl. xi, fig. 5*.
1836. *P. lævis*, J. de C. Sowerby, pag. cit., pl. xi, fig. 5.
1845 (?). *P. unguis*, A. Reuss, Böhmischen Kreideformation, p. 17, pl. v, fig. 44.
1850. *P. unguis*, H. B. Geinitz, Das Quadersandsteingebirge, p. 100.
1850. *P. lævis*, H. B. Geinitz, ibid.
1851. *P. unguis*, C. Darwin, Pal. Soc. Monogr. Foss. Lepadidæ, p. 64, pl. iv, fig. 1.
1853. *P. unguis*, C. Darwin, Ray Soc. Monogr. Sub-class Cirripedia, Synopsis et Index Systematicus, p. 637.
1865. *P. unguis*, Salter & Woodward, Cat. and Chart. Foss. Crustacea, p. 27, pl. i, fig. 6.
1877. *P. unguis*, H. Woodward, B.M. Cat. Brit. Foss. Crustacea, p. 141.
1886. *P. unguis*, J. Kafka, Sitz. Ber. k. Böhm. Gesell. Wiss., Prag, 1885, p. 573.
1887. *P. unguis*, Fritsch & Kafka, Crust. Böhmischen Kreidef., p. 12.

This common Gault species was founded by J. de C. Sowerby on a rostrum and one of the latera of the lower whorl. Darwin (1851,

p. 64, pl. iv, fig. 1) figured a number of valves belonging to a single individual, namely, a carina, a pair of terga, a rostrum, a sub-rostrum, a pair of upper latera, a pair of latera of the lower whorl from the carinal end of the capitulum, and two other latera of this same whorl from one side of the rostral end of the capitulum. These are preserved in the Museum of Practical Geology, Jermyn Street. Darwin says of the scutum: "Although the scutum is, unfortunately, at present unknown, there can be scarcely any doubt that it would closely resemble that of *P. glaber*, and therefore I have not hesitated, in this instance, to break through my rule of exclusively taking the scutum as typical in *Pollicipes*: should, hereafter, a scutum be found in the Gault like that of *P. glaber*, it may, with considerable confidence, be named as belonging to this species."

4.

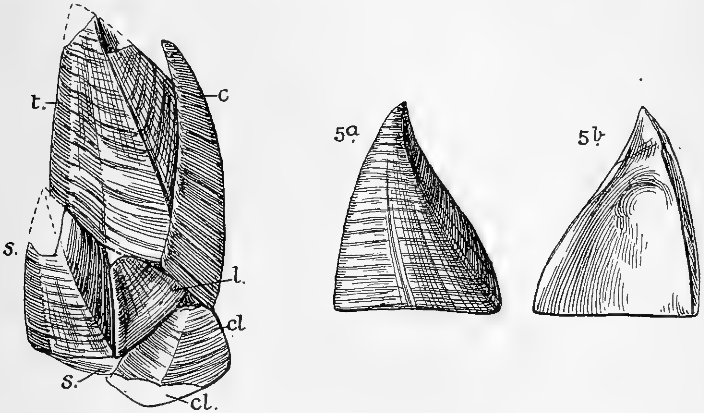


FIG.
4. *Pollicipes unguis*, J. de C. Sowerby. External view of the right side of part of a capitulum of a young individual. × 6 diam. Albian, Gault: Folkestone, Kent. B.M., I. 13523. *c.* carina; *s.* scutum; *t.* tergum; *l.* upper latus; *c.l.* carinal latus.
5a. Id. External view of right scutum of a much older individual. × 2 diam.
5b. Id. Inner surface of same, showing the deep pit for the adductor scutorum muscle.

In the British Museum (Natural History), registered I. 13523, there is a young example of *P. unguis*, with several of the valves of the capitulum in position (Fig. 4). The right side of the capitulum is uppermost, and shows the carina, scutum, tergum, upper latus, and carinal latus. Its importance lies in the fact that the valves are almost in their original positions, and that it includes the scutum, which has not been described previously. The portion of the capitulum preserved is twice as long as wide. Its greatest length is 9 mm. and its greatest breadth 4·5 mm. With the exception of the scutum the various valves of *P. unguis* have been fully described by Darwin, and in these circumstances it is proposed here to describe the scutum alone.

The description of the external characters of the scutum is based mainly on that valve seen in the young individual (Fig. 4) and on a much larger scutum of another individual (Figs. 5*a*, *b*). The description and figure of the inner surface of the scutum is taken from the larger valve, now in my possession.

Description of Scutum.—General outline approaching an equilateral triangle, convex, moderately thick, divided into two unequal portions by a ridge extending from the apex to the basi-lateral angle, the occludent portion being about twice as wide as the tergo-lateral portion. A further ridge extends from the apex to about the middle of the basal margin, slightly nearer the rostral angle; basal margin almost straight, making with the occludent margin an angle of about 71°, and with the tergo-lateral margin an angle of about 63°; occludent margin slightly convex; tergo-lateral margin protuberant near the base, and incurved towards the apex; rostral angle sharp; basi-lateral angle blunt. Surface of valve almost smooth, with fine longitudinal striæ, which are more strongly marked in some specimens. The deep pit for the adductor scutorum takes up the whole of the lower two-thirds of the valve. From the top of this pit a depression runs to the apex. This depression, which is marked with fine oblique lines, extends on one side to the tergo-lateral margin, and on the other is bounded by the inner occludent margin, which is the same width the whole length of the valve. Length of occludent margin (from apex to rostral angle) 14 mm., length of basal margin 11·5 mm., length of tergo-lateral margin (from apex to basi-lateral angle) 15·5 mm.

Horizon and Locality.—Albian, Gault: Folkestone, Kent.

Comparison with other Species.—Darwin (1851, p. 67) says of *P. unguis*: "As before remarked, this species is very closely related to the cretaceous *P. glaber*, of which it is evidently the representative in the Gault; the chief difference consisting in the more elongated form and greater size of its upper latera, which, in *P. unguis*, exceed half the length of the tergum, whereas in *P. glaber* they are only one-third of its length. The carina, in the present species, has its basal margin, perhaps, less pointed, and has a narrow linear channel along its edges; but I am not at all sure that this latter character does not vary. Lastly, the anterior lower latera in *P. unguis* are thinner, and rather more convex, with the basal margin more arched and protuberant, with the external oblique ridge very much more central." The scutum of *P. unguis*, as expected by Darwin, is extremely like that of some forms of *P. glaber*, and apparently differs only in being much thicker. Some of the differences between the various valves of *P. unguis* and *P. glaber* given by Darwin are not apparent in some specimens. There is much variation in the valves of both species, and it is highly probable that some of the differences will eventually be correlated with the differences of horizon. Consequently, until a larger number of specimens of both species from definite horizons have been examined, it is not advisable to attempt to point out probable differences. *P. unguis* is confined to the Gault, and *P. glaber* ranges right up into the Upper Senonian.

My thanks are due to Dr. F. A. Bather, Mr. G. C. Crick, and Mr. C. P. Chatwin for help in connexion with this paper.

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V.—The Plasticity of Rocks and Mountain Building.

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

British geologists must have read Professor Coleman's Address to the Geological Section of the British Association with great pleasure and interest. As Professor Coleman remarks, geology finds some of its most seductive problems in the neglected extremes of the earth's history. Out of the apparent tangle of the 'drifts' and Archæan Gneisses Canadian geologists are now evolving an orderly sequence which must exercise considerable influence upon the progress of geology in other lands. The seemingly unnatural conjunction of Pleistocene and Archæan, Professor Coleman states, has furnished the clue to certain puzzling problems of the Archæan.

During a trip from Regina to Winnipeg this summer I had the pleasure of riding at the end of a Canadian Northern train with a young railway engineer, and discussing with him the problems that have to be faced to keep the line in good condition during the winter. In many places the line passes over areas of waterlogged ground. During the winter the cold penetrates the earth and freezes this water to depths of 10 feet or more. The ice thus formed expands, raises the earth into domes and makes the road bed very irregular. It is the business of the engineer to see that these irregularities are made good by packing up the line, a troublesome task with the temperature many degrees below zero F.

The 'Canadian shield' consists of a base of granite or gneiss rising into numerous domes which are somewhat irregularly scattered over the area. Upon them rest the Keewatin and newer rocks. After the deposition of the Keewatin Series the land rose and formed a great mountain system, which was afterwards almost completely destroyed by denudation.

The rising of this mountain system seems to have been due to the heating up of portions of what are now known as the Laurentian granites, rather than to crushing or folding. We must regard the mountain ranges as floating upon the earth's crust, their lightness being due either to their high temperature bases or small relative density. Crushing and folding, apart from the heating that may result from it, do not seem competent to alone form high mountain systems; for the folds would not cause a great rise of the surface—the mass would sink as do the sediments deposited upon a sea-bottom. It seems most reasonable to regard mountain ranges as being due to the high temperature of the deep-seated rocks causing an uplift by expansion, just as the railway track is lifted by the freezing of the water beneath. If this view be the correct one, then it follows that the disappearance of the mountain range must have been due to the cooling down of the Laurentian rocks beneath; for otherwise the mountain peaks would have risen as fast as they were denuded.

Professor Coleman gives a very interesting explanation of the reason for the formation of the dome-shaped masses of granite and gneiss upon which the Keewatin rocks rest. He suggests that the lower rocks became plastic, that the Keewatin above was unequally heavy, and that the granite rose in domes where the lightest loads were situated.

It must be admitted that the formation of great depressed areas, such as that of Lake Superior, is a difficulty. Here it is considered that the granite below became so fluid that it was ejected at the edges and allowed the area from beneath which it came to sink bodily. But if such be the case, how is it that this portion of the earth's crust did not rise again? It may be that to some extent the explanation is that the deeper portions of the earth's crust are plastic, not viscous. Plastic materials do not flow unless the stress exceeds some particular limit. A mountain range may therefore be stable although its height may be hundreds of feet greater or less than is warranted by the density of the crust at the spot.

Professor Coleman recognizes that the weight of the ice which once rested on the 'Canadian shield' depressed it, and that since the ice melted away there has been a rise of the area. He says these sinkings and risings must be accomplished by plastic flow outwards from beneath the loaded area, and inwards towards the area relieved of its load. He rightly uses the word plastic here. And here is another contrast between the properties of the ice-sheets which played an important part in the formation of some Canadian deposits and the rocks themselves. The ice moved much as a truly viscous liquid would have done whilst the deep-seated rocks underwent plastic deformation. The ice formed and maintained an almost level upper surface like that of the Antarctic Plateau, whilst the plastic rocks allowed themselves to be cut into hill and dale until the stresses produced were sufficiently great to allow of plastic flow. Plastic solids never reach a condition in which the stresses are equal in all directions; they cease to flow when the stress falls below some particular value. Although it is true that the solid, liquid, and gaseous states are continuous, the liquid differs from the plastic solid inasmuch as it yields to any stress however small, whereas the solid does not begin to deform continuously until the unbalanced stress reaches some particular value depending upon the nature of the material and the temperature. With rise of temperature this limiting stress becomes smaller and smaller, and when it falls to zero the solid becomes a liquid. For all practical purposes, however, substances which flow (shear) under very small stresses may be regarded as viscous (liquids). Professor Coleman shows that although the 'Canadian shield' was depressed by the weight of the Pleistocene ice resting upon it, it has not risen as much as might have been expected considering the weight of ice melted away; probably this is also owing to the *plastic* nature of the earth's crust.

There is another interesting property of plastic substances which might be referred to. When a test bar of iron or steel is drawn out to some extent in a testing machine and its length then measured, it will be found that, after giving it a light blow, it will have shortened again somewhat. If the bar has suffered compression it will have lengthened again. In many cases it has been found that an earthquake has resulted in a rise or fall of the land locally. May it be that the jar of the strained plastic crust has released strains in a similar manner and given rise to sudden change of form?

VI.—Note on the Type-specimens of *Ammonites cordatus* and *Ammonites excavatus*, J. Sowerby.

By G. C. Crick, F.G.S., British Museum (Natural History).[1]

J. SOWERBY'S type-specimens of *Ammonites cordatus* and *Ammonites excavatus* have been dealt with comparatively recently by Miss M. Healey in the *Palæontologia universalis* (sér. II, fasc. 1, August, 1905, Nos. 94, 94*a*, and 92, 92*a*, 92*b* respectively), but her statements require a little modification in some details. Both specimens are in the British Museum collection, and were described and figured in the *Mineral Conchology*.

1. *Ammonites cordatus*.—Miss Healey gives the date of publication of this species as 1812, and observes that "The date 1813 is given on the plate, but on the title page the date is 1812". From this remark

[1] Published by permission of the Trustees of the British Museum.

it is obvious that the date of publication of the species was taken from the title-page of vol. i, this bearing the date 1812. But, as is well known, the *Mineral Conchology* was issued in 113 numbers or parts, the first sixty-five parts being by James Sowerby, and the rest by his son, James de Carle Sowerby. Vol. i included Nos. i–xviii, which appeared between 1812[1] and August, 1815. The figures and description of *Ammonites cordatus* (pp. 51–2, pl. xvii, figs. 2 and 4) were published in No. iv, which is dated April 1, 1813, the same date appearing on the plate. It is obvious, therefore, that the date of publication of the species is not 1812, but 1813.

Sowerby figured two specimens (figs. 2 and 4), but regarded the original of his fig. 2 as the type of his species; for, referring to the fossil represented in his fig. 4, he says: "I am much inclined to consider it as a distinct species." The original of fig. 2 is therefore the holotype, and that of fig. 4 a paratype. Respecting the paratype Miss Healey states: "The difference between the photograph of the paratype and the original figure [fig. 4] is striking, but there can be no doubt about its identity, as it bears a label on which is written in Sowerby's handwriting (*Ammonites cordatus*, M.C. 17, fig. 2, 4) and the green wafer with which he marked figured specimens." As will be seen from a comparison of Sowerby's figure of the holotype with the photograph of the same given in the *Palæontologia universalis*, Sowerby's figure is reversed; but it would seem from the figures of the paratype given on the same plate of the *Palæontologia universalis* that in this case Sowerby's figure was not reversed. However, a careful examination of the paratype, especially of the septal surface at the anterior end of the specimen, shows that Sowerby's figure, so far as the outer whorl is concerned, is reversed; and that the inner whorls have been drawn from the opposite side of the specimen. So far, then, as the outer whorl is concerned, the photograph reproduced in the *Palæontologia universalis* represents the opposite side of the specimen to that figured in the *Mineral Conchology*, and, in a great measure, accounts for the striking differences between the figure in the *Palæontologia universalis* and Sowerby's figure. Even if the specimen had not been labelled in Sowerby's handwriting, there could be no doubt whatever about its identity, since the details of the septal surface at its anterior end have been carefully copied in Sowerby's figure.

2. *Ammonites excavatus.*—Miss Healey gives the date of publication of this species as 1818. It is true that this is the date on the title-page of the volume (vol. ii) in which that species was described and figured (p. 5, pl. cv), but, as has been mentioned above, the *Mineral Conchology* was published in numbers or parts; and vol. ii included Nos. xix–xxxv, which were issued between October 1, 1815, and June 1, 1818, both dates inclusive. The figure and description of *Ammonites excavatus* appeared in No. xix, which is dated October 1, 1815. The date of publication of the species should therefore be 1815, and not 1818.

[1] The dedication of the work, and each plate in No. i, which included pls. i–iii with explanatory text, is dated May 25, 1812.

There are considerable differences between Sowerby's figure and the photograph of the type-specimen reproduced in the *Palæontologia universalis* (sér. II, fasc. 1, No. 92*a*), but it should be mentioned that Sowerby's figure, besides being reversed (as usual) and somewhat restored, represents the fossil *without* the natural internal cast of the body-chamber (which, as Sowerby himself observed, is separated from the rest of the shell), whilst in the photograph this portion of the fossil has been placed in its natural position.

VII.—Notes on the Morphology and Generic Nomenclature of some Carboniferous Arachnida.

By R. I. Pocock, F.L.S., F.Z.S.

1. On *Anthracomartus* and *Promygale*.

In his monograph of Palæozoic Arachnida published in 1904, Dr. Fritsch divides the order Araneæ into two suborders—the Arthrarachnæ, Haase, containing the Arthrolycosidæ, and the Pleuraraneæ, Fritsch, containing the Hemiphrynidæ (*Hemiphrynus*) and the Promygalidæ (*Promygale*).

Haase, Beecher, and others, whom Fritsch follows, were no doubt right in referring *Arthrolycosa* and allied genera to the order Araneæ, but the Pleuraraneæ are in my opinion nothing but Anthracomarti, the genus *Promygale* itself being synonymous with *Anthracomartus*. The form of the carapace and structure of the appendages are the same in the two. The constriction between the prosoma and opisthosoma occurs in both. The segmentation of the opisthosoma is similar in the two, even in the presence of a longitudinal sulcus dividing the pleural laminæ into an external and an internal moiety, and in the angulation of the posterior border of the posterior sternal plates.

Certain discrepancies in the figures published by Fritsch inevitably rouse a feeling of scepticism on the score of the accuracy of the restorations they represent. In *Promygale bohemica* (fig. 20) there are eight dorsal plates; each of the anterior seven is furnished with a divided pleural lamina, the posterior border of the eighth being produced in the middle line to form an unpaired plate. But in fig. 21, showing the ventral side, the last-mentioned plate is paired by a longitudinal sulcus. In *P. elegans* (fig. 26*a*, dorsal view), on the other hand, there are only seven dorsal plates. On the seventh the inner moieties of the pleural laminæ are not shown, but on each side of the opisthosoma ten sclerites represent the outer moieties of these laminæ. It is impossible to refer these with any certainty to their appropriate somites, and impossible to say which of the original seven pleural laminæ have been subdivided to add to the number. A similar augmentation is shown in fig. 23, representing *P. rotundata*. This feature, if existent, should constitute a generic difference between *P. bohemica* on the one hand and *P. elegans* and *P. rotundata* on the other; but the drawings of the actual specimens of *P. elegans* (pl. xv, fig. 2) and of *P. rotundata* (text-fig. 24, p. 20) afford, so far as I can see, no support to the view that the pleural laminæ are numerically in excess of the somites. On the contrary, there appears to be complete agreement between them in this particular.

Again, in the dorsal view of *P. bohemica* (text-fig. 20, p. 19), the outer moieties of the posterior four pairs of pleural laminæ are marked with an additional concentric sulcus, which is continued across the unpaired lamina of the last tergal plate. This is no doubt the sulcus defining on the ventral side the outer plate of the laminæ, which is present in all the well-preserved specimens of *Anthracomartus* that I have seen.

One other difference, already referred to, between *Promygale bohemica* and the species of *Anthracomartus* is the presence in the former, to judge from the drawings, of an additional tergal plate, cut off by a sulcus from the posterior half of the seventh tergum, making eight of these plates visible on the dorsal side. Apart from the fact that this plate is not so divided, either in *Eophrynus*, *Anthracosiro*, or *Anthracomartus*, a fact sufficient in itself to cast doubts upon the reality of its segmentation in *Promygale bohemica*, it is noticeable that Fritsch himself omits the sulcus in question from his drawing of *P. elegans* (fig. 26, p. 21), and thus does not ascribe even a generic value to its presence in *P. bohemica*. Without further evidence I find it hard to believe in its existence.

With regard to the restoration of the ventral side of the same species (text-fig. 21), since the posterior margins of the sterna are represented by dotted lines, it may be assumed that these plates were cracked and obliterated beyond the possibility of accurate decipherment. All the more remarkable, therefore, must be regarded the circumstance that the so-called comb-like organs are so well preserved as to admit of detailed restoration. I suggest that these alleged organs are really the two deep impressions which lie, one on each side, of the anterior sternal plates in *Anthracomartus*. The settlement of this question, however, must be left until an opportunity of examining the fossil has been afforded to some competent Arachnologist.

Respecting the shape of the sternal plates as indicated on this drawing, it is noticeable that Fritsch has represented them by dotted lines running parallel with each other and at right angles to the longitudinal axis of the body, whereas the drawing of the original specimen of *P. elegans* (pl. xv, fig. 4) shows quite clearly that the sterna, at least in the posterior part of the body, are angularly curved in the middle line, exactly as in the examples of *Anthracomartus* that I have seen, thus establishing another point of similarity between this genus and *Promygale*.

In referring the genus *Promygale* to the Araneæ and *Anthracomartus* to the Opiliones, in spite of the striking similarity between them, Fritsch relies upon his alleged discovery of jointed appendages, representing the spinning mamillæ of the Araneæ, upon the lower side of the opisthosoma in *Promygale* and their absence in *Anthracomartus*. In the restoration of *P. elegans* (text-fig. 26, B, p. 31) these appendages are shown as two pairs of slender three- or four-jointed limbs attached to the second and third sternal plates, each limb of a pair being widely separated from its fellow of the opposite side. I cannot think the drawings of the original specimens justify this conclusion. In fig. 3, pl. xv, showing the ventral side of *P. elegans*, the author has portrayed pieces of what he regards as small limbs scattered without order, amongst other foreign bodies, over the exposed surface of the ventral side of the opisthosoma. Each piece consists of three or four segments, but they differ from each other so greatly in length and thickness that no successful attempt can be made to pair or homologize them. Moreover, no clue is afforded as to their original situation, and it is permissible to suggest that perhaps after all they are not appendicular in nature but fragments of the sternal skeleton; or indeed they may not belong to the organism at all like the so-called parasitic Spiroglyphs with which the fossil is strewn. And if appeal be made to fig. 4 on the same plate, representing the ventral side of another specimen, referred to the same species, and showing what might be interpreted as a pair of stout two-jointed limbs diverging from each other and from the middle line a little in front of the centre of the lower surface of the opisthosoma, it may be replied that, apart altogether from being in contact in the middle line, these segments bear no sort of resemblance to the restored opisthosomatic limbs depicted by Fritsch. I venture to suggest that, if appendicular in nature, the segments in question belong to one of the prosomatic appendages misplaced. But the angle they form coincides suspiciously with the angular curvature of the sterna of the mid region of the opisthosoma in *Anthracomartus*. In the specimens of the latter genus that I have seen, as well as in Ammon's drawing of *A. palatinus*, the borders of the sterna show up as angular ridges, the anterior and usually the strongest lying near the middle of the opisthosoma.

With respect to the eyes, two pairs are represented in the restoration of *Promygale bohemica*; but the drawing of the original specimen shows only a single pair placed differently from either of the pairs outlined in the restoration.

Since, then, critical examination of Fritsch's drawings of *Promygale* fails to produce any trustworthy evidence that this genus can be separated from *Anthracomartus*, there is no choice but to regard the two as identical.

As regards the Hemiphrynidæ, I have no doubt that these Arachnida must also be assigned to the Anthracomarti, since, so far as can be judged, they have the characters of that order. Most emphatically they do not belong to the order Araneæ. The genus *Hemiphrynus* was based upon two species—*H. longipes* and *H. hofmanni*; but since these cannot be congeneric, if the restorations approach reality, I propose to select *H. hofmanni* as the type.

The following features in Fritsch's restoration of *Anthracomartus* call for comment (text-fig. 41, A dorsal, B ventral side). In the figure representing the dorsal side, the palpi (appendages of the second pair) show six segments with a terminal knob, projecting beneath the fore border of the carapace. The subequality in the length of the segments is quite unusual in the Arachnida, and if the terminal knob be a segment there is one segment in excess of the normal found in the class. The following four pairs of appendages consist of eight segments, including the coxæ. This number also exceeds by one the normal found in Arachnida, the additional segment arising from the division of the femur. But in the first two pairs of these appendages the proximal segment of the femur is twice the length of the distal, whereas in the last two it is only one-third of the length. Since the femora are sometimes segmented in the Chelonethi (Pseudoscorpiones), it would be rash to reject unhesitatingly on *a priori* grounds Fritsch's restoration of the legs in *Anthracomartus*; but since the legs of the specimens of the genus that I have seen, as well as of the allied genera *Eophrynus* and *Anthracosiro*, have normal and unsegmented femora like a great majority of the Arachnida, there can be very little doubt, I imagine, that Fritsch has mistaken fortuitous cracks for intersegmental joints. And this is by no means a solitary case where a knowledge of the constancy of certain morphological features in the Arachnida enforces the imposition of such an interpretation upon his restorations.

2. On the Structure and Classification of the Phalangiotarbi.

The name Phalangiotarbi was proposed by Haase in 1890 for a group accorded subordinal rank under the Opiliones. It contained the genus *Phalangiotarbus* created for the species described by Dr. Henry Woodward as *Architarbus subovalis.* I agree with Haase in thinking the type-species of *Architarbus* and *Phalangiotarbus* generically distinct, and with Fritsch in regarding them as belonging to the same order of Arachnida. But whereas Fritsch referred them to a family of Opiliones, the Architarbidæ, it appears to me necessary to give them higher systematic rank. I therefore retain the term Phalangiotarbi, leaving open for the moment the question of their right to inclusion in the Opiliones. In addition to the genera just mentioned I assign to this group *Geratarbus*, *Geraphrynus*, and the new genus *Opiliotarbus* described below.

The morphology of this series of genera has hitherto baffled research; and I am indebted to well-preserved material kindly lent to me by Dr. Wheelton Hind, Mr. S. Priest, the late Mr. W. Madeley, Mr. H. Johnson, F.G.S., and Mr. Walter Egginton for the new interpretation of the facts set forth in the following pages.

Since more than one species has in some cases been referred to the genera, I take this opportunity of stating that the type-species of each is as follows: *Architarbus*, Scudder, 1868; type, *A. rotundatus*, Scudder. *Geraphrynus*, Scudder, 1884; type, *G. carbonarius*, Scudder. *Geratarbus*, Scudder, 1890; type, now selected, *G. lacoei*, Scudder. *Phalangiotarbus*, Haase, 1890; type, *Architarbus subovalis*, H. Woodw. *Opiliotarbus*, nov.; type, *Architarbus elongatus*, Scudder.

In the diagnosis of *Geraphrynus* published by Scudder in 1890, the genus is said to possess a "posterior shield of the cephalothorax, the anterior triangular fragment of which slopes upwards to the ridge [of the cephalothorax], while the hinder portions with their transverse scorings and ridgings lie on a plane below . . . this post-thoracic plate crowds down the middle of the six following segments".

Comparing the dorsal and ventral views of my specimens of *Geraphrynus* with Scudder's figure of *G. carbonarius*, I am forced to conclude that the so-called post-thoracic plate has no existence as such, but is composed of the anterior two or three sternal plates of the opisthosoma and the posterior projection of the carapace. It is the latter area which "crowds down the middle of the six following segments"; the sternal plates are the anterior "triangular fragment" sloping upwards to the ridge as well as the "hinder portions with transverse scorings and ridgings" that "lie on a plane below"; and the median ridge is the sternal area of the prosoma. In a crushed specimen confusion might easily arise between these dorsal and ventral elements of the skeleton.

This interpretation, if correct, disposes of Haase's view of the morphology of *Architarbus*. This author modified Scudder's drawing to suit his idea that *Architarbus* belongs to the Amblypygous Pedipalpi. The anterior part of Scudder's post-thoracic plate he regarded as the posterior sternal plate of the prosoma and its posterior part as the genital plate of the opisthosoma. Scudder's drawing, however, does not justify Haase's rendering of it, full of ingenuity though his interpretation was.

Commenting on Haase's opinion, Hansen states that of the three specimens figured by Scudder as *G. carbonarius* "only one, the one figured on pl. xl, fig. 12, can with any certainty be classed amongst the Amblypygi"; and in an explanatory foot-note he adds that the figure shows eleven distinct sternites of exactly the same shape as those of *Phrynus*. This statement, however, is not true. No *Phrynus* has four narrow sterna following and curving round the genital plate nor the posterior sterna so well defined and large as shown in Scudder's figure. Hansen, moreover, ignores the existence of the plates in front of the backwardly bulging plate which, by implication, he takes for the genital operculum; and he is compelled to assume that the first pair of appendages exhibited by the fossil has been quite wrongly drawn. He seems, in fact, to trust to the accuracy of the drawing where it compares favourably, as he thinks, with a *Phrynus*, and assumes inaccuracy where the discrepancies are irreconcilable. The figure admittedly resembles a *Phrynus* superficially. So much so, indeed, that I feel sure the artist, Mr. H. Emerton, made use of a *Phrynus* to help his delineation; and this supposition is borne out by certain discrepancies between Scudder's description of the fossil and Emerton's figure of it.

The difficulties, then, that have hindered the understanding of the skeletal morphology of these fossil Arachnida are due to confusion between the dorsal and ventral elements. It appears to me that in nearly all cases the dorsal surface is exposed; but that owing to the removal or crushing of the carapace the underlying coxæ and sternal area of the prosoma and the anterior sternal plates of the opisthosoma are also shown. The figures of the following species bear out this view: *Architarbus rotundatus*,[1] *Geraphrynus carbonarius*,[2] *Geraturbus lacoei*,[3] *Phalangiotarbus subovalis*.[4]

Judging from the figures published by Fritsch and Scudder of the species they name *Geraphrynus* (or *Architarbus*) *elongatus*, and from the material I have examined, I am convinced that in this group the

[1] Geol. Survey, Illinois, 1868, p. 568.
[2] Mem. Bost. Soc. Nat. Hist., vol. iv, pl. xl, figs. 1, 10, 12.
[3] Ibid., fig. 11.
[4] Geol. Mag., Vol. IX, p. 385, 1872 (*Ph.* '*Architarbus*' *subovalis*, H. Woodw.).

carapace is large, unsegmented, and has either a straight or convex or considerably produced posterior border; at least, the coxæ of the four posterior pairs of appendages are large and radiate from a central broader or narrower sternal area. The dorsal surface of the opisthosoma consists of five or six straight or curved but always short or very short anterior terga, and of three or four much longer posterior terga; and the ventral surface of seven, possibly eight, sternal plates, of which the posterior are long and the anterior short, the first being triangular and wedged between the coxæ of the last pair of legs.

The following notes on the genera above mentioned will explain my reasons for admitting them:—

1. In *Phalangiotarbus subovalis* the anterior five terga of the opisthosoma are short and straight, and the posterior three large, there being eight in all. The posterior border of the carapace is straight, the anterior border widely rounded. The chief peculiarities of the genus, however, lie in the facts that the sternal area of the prosoma is large and oval and that the coxæ of the legs of the first pair do not meet in the middle line beneath those of the palpi. Only one specimen of this genus has been discovered, and I judge of its character from the figure published by Dr. Woodward.

2. *Architarbus*, represented by the single species *rotundatus*, has the carapace rounded in front and strongly produced in the middle line behind, with the anterior terga of the opisthosoma curved round its bulging area. There are nine terga in the opisthosoma, and they appear to increase progressively in length from before backwards, the anterior five or six being short. The sternal area of the prosoma is small and subcircular, and round it radiate four pairs of coxæ of the ambulatory limbs, those of the first pair meeting in the middle line and concealing the basal segments of the palpi. This species is only known to me from Scudder's figure and description.

3. *Geraphrynus* has the carapace angular in front and convex or produced behind. The opisthosoma has nine terga, the posterior three being much longer than the anterior six, two or more of which follow the curvature of the carapace. The sternal area of the prosoma is long and narrow, and the coxæ of the legs of the first pair meet in the middle line and underlie those of the palpi, as in *Architarbus*. From the latter *Geraphrynus* seems to be separable by the anterior angulation of the carapace, the long and narrow sternal area of the opisthosoma, and the marked enlargement of the posterior three terga of the opisthosoma. When characterized in 1884 [1] this genus was based upon a single species represented by a specimen from Mazon Creek, Illinois. In 1890 the species was redescribed by Scudder,[2] several additional specimens being used for the purpose, but it is quite clear from the context that the example illustrated by fig. 10, pl. xl of the later work is the type. It is from the figure and description of this specimen and from examples of other species in my hands that the characters of the genus have been taken. Beyond recording my belief

[1] Proc. Amer. Acad. Arts & Sci., vol. xx, pp. 17–18.
[2] Mem. Bost. Soc. Nat. Hist., vol. iv, pp. 446–7.

that the other specimens described by Scudder as *G. carbonarius* were correctly referred to the genus *Geraphrynus*, despite the opinion of Hansen, I have nothing further to say about them. I cannot find any characters to justify the separation of *Hadrachne*, Melander,[1] from *Geraphrynus*.

4. *Geratarbus* was based upon two species, *G. scaber* and *G. lacoei*, which apparently belong to different orders of Arachnida, *G. scaber* being probably one of the Ricinulei. I select *G. lacoei*, therefore, as the type. Judging from the figure and description of *G. lacoei*, it seems that the posterior border of the carapace in *Geratarbus* is straight; the opisthosoma has nine terga, of which the anterior five are short and straight from side to side and the posterior four much longer, gradually increasing in length from the sixth to the ninth, the ninth equalling the sum of the seventh and eighth. The sternal area of the prosoma is narrow and elongate, and the coxæ of the first pair of legs meet only at their proximal ends and diverge at an acute angle. *Geratarbus* differs from *Geraphrynus* and *Architarbus* in the straightness of the posterior border of the carapace and of the anterior terga of the opisthosoma, in the difference in relative size of the posterior terga, and in the divergence of the anterior coxæ.

5. *Opiliotarbus*, nov. Carapace evenly rounded in front, its postero-lateral angles squared, and its posterior border straight. Opisthosoma nearly parallel-sided, somewhat widely rounded at its anal extremity, with apparently the normal number of sterna but only eight terga, of which the anterior five are short and straight and the posterior three very large. Sternal area of prosoma small, oval, longer than wide. Coxæ of legs of first pair in contact throughout. Type, *Architarbus elongatus*, Scudd.,[2] 1890, from Mazon Creek, Braidwood, Illinois.

Fritsch[3] published figures and descriptions of what he believed to be the dorsal and ventral views of Scudder's type of this species. So far as the dorsal surface is concerned this view is probably correct; but it is perfectly clear that the figure of the ventral side, if approximately accurately drawn, was taken from another specimen. I have no doubt that it represents a species of *Geraphrynus*. Neither in its proportions nor in the position of its limbs can it be made to agree with Emerton's figure of the ventral view of the type or with Fritsch's own figure of the dorsal view of the latter.

Opiliotarbus has the posterior border of the carapace and the anterior terga of the opisthosoma straight as in *Geratarbus*, but it differs from that genus in having only eight terga on the opisthosoma, of which five are short and three very long.

When the characters of the genera above described are analysed, it seems that *Phalangiotarbus* stands quite apart from the others in the large size of the sternal plate of the prosoma and the wide separation of the coxæ of the legs of the first pair. For this reason I propose to follow Haase and refer it to a distinct family, Phalangiotarbidæ. To comprise the rest the family name Architarbidæ is available.

In the following key to the genera I have juxtaposed them

[1] Journ. Geol. Chicago, vol. xi, p. 179, pl. v, fig. 1, and pl. vii, fig. 1, 1903.
[2] Mem. Bost. Soc. Nat. Hist., vol. iv, p. 449, pl. xl, fig. 1 (ventral view).
[3] Pal. Arachn., pp. 33, 34, fig. 37A (dorsal view), *not* fig. 37B.

according to my conception of their affinities based upon the figures and descriptions. If the latter are erroneous with respect to the distinctive particulars relied upon, *Opiliotarbus* and *Geraphrynus* will probably fall as synonyms of *Geratarbus* and *Architarbus* respectively.

a. Sternal area of prosoma elliptical and wide; coxæ of legs of first pair not meeting in the middle line beneath those of the palpi; opisthosoma with eight terga, the anterior five short and straight, the posterior three long. Fam. Phalangiotarbidæ (*Phalangiotarbus*).
a'. Sternal area of prosoma quite narrow, generally linear; coxæ of legs of first pair meeting in the middle line beneath those of the palpi . Fam. Architarbidæ.
  b. Posterior border of the carapace straight; the anterior terga of the opisthosoma also straight.
    c. Opisthosoma with only eight tergal plates, the sixth three times as long as the fifth and three times as wide as it is long . . . *Opiliotarbus.*
    c'. Opisthosoma with nine tergal plates, the sixth twice as long as the fifth and five or six times as wide as it is long . . . . *Geratarbus.*
  b'. Posterior border of the carapace evenly convex or considerably produced in the middle line; opisthosoma with nine tergal plates, of which at least the first and second are curved round the posterior border of the carapace.
    d. Sternal area of the prosoma short and subcircular; terga of the opisthosoma progressively increasing in length from before backwards . *Architarbus.*
    d'. Sternal area of the prosoma long and narrow; last three terga of the opisthosoma markedly longer than the others . . *Geraphrynus.*

VIII.—Note on the Discovery by Professor C. de la Torre of Fossil Mammals in Cuba.

By Dr. J. W. Spencer, M.A., B.A.C., etc.

At the recent meeting of the International Geological Congress in Stockholm, Professor C. de la Torre, of the University of Havana, made the announcement of a discovery of fossil mammals of Pleistocene age, in cavern deposits of Central Cuba. Hitherto the known fossil Vertebrates were few. Mr. T. W. Vaughan, in America, had published a long paper discrediting those previously reported, but before that time the late Professor E. D. Cope (America's great Vertebrate Palæontologist) had passed over the doubtful forms, and accepted especially one species of Edentate, supposing that other forms were buried and submerged during the subsequent depressions of the land.

Professor de la Torre's investigations have now established Cope's hypothesis that many other fossil mammals occur in Cuba. Some of the specimens, representing half a dozen species of Rodents, Edentates, and other forms, were shown at Stockholm, while others are at the Central Port Museum, New York, under Professor Osborn.

It may be added that the writer has also found the remains of *Amblyrhiza* (a Rodent as large as a deer) in a cavern on St. Martin, one of the north-eastern of the West Indian Islands—a notice of its occurrence in that island not having been published until the present time.

Apart from the palæontological interest, the value of this great discovery of fossils lies in its confirmation of the recent connexion of the islands with the continent, and the late high continental elevation as shown in the "Reconstruction of the Antillian Continent" in 1895, previously reviewed in this Magazine. Similar evidence of great continental changes of level in Europe have been brought forward by Professor Edward Hull of this country, by Dr. Fridjof Nansen of Norway, and by others.

Professor de la Torre's investigations have also great interest in another field, for he has obtained a Jurassic fauna, which had been previously discovered, but later pronounced wanting in Cuba, by Mr. C. W. Hayes. Professor de la Torre is to be congratulated on his successful researches in geological problems of such great importance and of international interest which have a bearing on the question of cause of the Glacial period.

NOTICES OF MEMOIRS.

I.—British Association for the Advancement of Science. Sheffield, 1910. Address by the Rev. Professor T. G. Bonney, Sc.D., LL.D., F.R.S., President.

(*Concluded from the October Number, p.* 469.)

SUCH, then, are the facts, which call for an interpretation. More than one has been proposed; but it will be well, before discussing them, to arrive at some idea of the climate of these Islands during the colder part of the Glacial Epoch. Unless that were associated with very great changes in the distribution of sea and land in Northern and North-Western Europe, we may assume that neither the relative position of the isotherms nor the distribution of precipitation would be very materially altered. A general fall of temperature in the northern hemisphere might so weaken the warmer ocean current from the south-west that our coasts might be approached by a cold one from the opposite direction.[1] . . . I am doubtful whether we can attribute to changed currents a reduction in British temperatures of so much as 11°; but, if we did, this would amount to 28° from all causes, and give a temperature of 20° to 22° at sea-level in England during the coldest part of the Glacial Epoch. That is now found, roughly speaking, in Spitzbergen, which, since its mountains rise to much the same height, should give us a general idea of the condition of Britain in the olden time.

What would then be the state of Scandinavia? Its present temperature ranges on the west coast from about 45° in the south to 35° in the north. But this region must now be very much, possibly 1800 feet, lower than it was in pre-Glacial, perhaps also in part of Glacial, times. If we added 5° for this to the original 15°, and allowed so much as 18° for the diversion of the warm current, the temperature of Scandinavia would range from 7° to –3°, approximately that of Greenland northwards from Upernivik. But since the difference at the present day between Cape Farewell and Christiania (the one in an abnormally cold region, the other one correspondingly warm) is

[1] Facts relating to this subject will be found in *Climate and Time*, by J. Croll, 1875, chs. ii and iii. Of course the air currents would also be affected, and perhaps diminish precipitation as the latitude increased.

only 7°, that allowance seems much too large, while without it Scandinavia would correspond in temperature with some part of that country from south of Upernivik to north of Frederikshaab. But if Christiania were not colder than Jakobshavn is now, or Britain than Spitzbergen, we are precluded from comparisons with the coasts of Baffin Bay or Victoria Land.

Thus the ice-sheet from Scandinavia would probably be much greater than those generated in Britain. It would, however, find an obstacle to progress westwards, which cannot be ignored. If the bed of the North Sea became dry land, owing to a general rise of 600 feet, that would still be separated from Norway by a deep channel, extending from the Christiania Fjord round the coast northward. Even then this would be everywhere more than another 600 feet deep, and almost as wide as the Strait of Dover. The ice must cross this and afterwards be forced for more than 300 miles up a slope which, though gentle, would be in vertical height at least 600 feet. The task, if accomplished by thrust from behind, would be a heavy one, and, so far as I know, without a parallel at the present day; if the viscosity of the ice enabled it to flow, as has lately been urged,[1] we must be cautious in appealing to the great Antarctic barrier, because we now learn that more than half of it is only consolidated snow.[2] Moreover, if the ice floated across that channel, the thickness of the boulder-bearing layers would be diminished by melting (as in Ross's Barrier), and the more viscous the material the greater the tendency for these to be left behind by the overflow of the cleaner upper layers. If, however, the whole region became dry land, the Scandinavian glaciers would descend into a broad valley, considerably more than 1200 feet deep, which would afford them an easy path to the Arctic Ocean, so that only a lateral overflow, inconsiderable in volume, could spread itself over the western plateau.[3] An attempt to escape this difficulty has been made by assuming the existence of an independent centre of distribution for ice and boulders near the middle of the North Sea bed[4] (which would demand rather exceptional conditions of temperature and precipitation); but in such case either the Scandinavian ice would be fended off from England, or the boulders, prior to its advance, must have been dropped by floating ice on the neighbouring sea-floor.

If, then, our own country were but little better than Spitzbergen as a producer of ice, and Scandinavia only surpassed Southern Greenland in having a rather heavier snowfall, what interpretation may we give to the glacial phenomena of Britain? Three have been proposed. One asserts that throughout the Glacial Epoch the British Isles generally stood at a higher level, so that the ice which almost buried

[1] R. M. Deeley, Geol. Mag., 1909, p. 239.

[2] E. Shackleton, *The Heart of the Antarctic*, ii, 277.

[3] It has indeed been affirmed (Brögger, *Om de senglaciale og postglaciale nivaforandringer i Kristianiafeltet*, p. 682) that at the time of the great ice-sheet of Europe the sea-bottom must have been uplifted at least 8500 feet higher than at present. This may be a ready explanation of the occurrence of certain dead shells in deep water, but, unless extremely local, it would revolutionize the drainage system of Central Europe.

[4] Geol. Mag., 1901, pp. 142, 187, 284, 332.

them flowed out on to the beds of the North and Irish Seas. The boulder-clays represent its moraines. The stratified sands and gravels were deposited in lakes formed by the rivers which were dammed up by ice-sheets.[1] A second interpretation recognizes the presence of glaciers in the mountain regions, but maintains that the land, at the outset rather above its present level, gradually sank beneath the sea, till the depth of water over the eastern coast of England was fully 500 feet, and over the western nearly 1400 feet, from which depression it slowly recovered. By any such submergence Great Britain and Ireland would be broken up into a cluster of hilly islands, between which the tide from an extended Atlantic would sweep eastwards twice a day, its currents running strong through the narrower sounds, while movements in the reverse direction at the ebb would be much less vigorous. The third interpretation, in some respects intermediate, was first advanced by the late Professor Carvill Lewis, who held that the peculiar boulder-clays and associated sands (such as those of East Anglia), which, as was then thought, were not found more than about 450 feet above the present sea-level, had been deposited in a great freshwater lake, held up by the ice-sheets already mentioned and by an isthmus, which at that time occupied the place of the Strait of Dover. Thus, these deposits, though directly due to land-ice, were actually fluviatile or lacustrine. But this interpretation need not detain us.

. . . .

Each of the other two hypotheses involves grave difficulties. That of great confluent ice-sheets creeping over the British lowlands demands, as has been intimated, climatal conditions which are scarcely possible, and makes it hard to explain the sands and gravels, sometimes with regular alternate bedding, but more generally indicative of strong current action, which occur at various elevations to over 1300 feet above sea-level, and seem too widespread to have been formed either beneath an ice-sheet or in lakes held up by one; for the latter, if of any size, would speedily check the velocity of influent streams.

. . . .

Some authorities, however, attribute such magnitude to the ice-sheets radiating from Scandinavia that they depict them, at the time of maximum extension, as not only traversing the North Sea bed and trespassing upon the coast of England, but also radiating southward to overwhelm Denmark and Holland, to invade Northern Germany and Poland, to obliterate Hanover, Berlin, and Warsaw, and to stop but little short of Dresden and Cracow, while burying Russia on the east to within no great distance of the Volga and on the south to the neighbourhood of Kief. Their presence, however, so far as I can ascertain, is inferred from evidence[2] very similar to that which we

[1] See Warren Upham, Monogr. U.S. Geol. Survey, xxv, 1896. This explanation commends itself to the majority of British geologists as an explanation of the noted parallel roads of Glenroy, but it is premature to speak of it as "conclusively shown" (Quart. Journ. Geol. Soc., vol. lviii, p. 473, 1902) until a fundamental difficulty which it presents has been discussed and removed.

[2] A valuable summary of it is given in *The Great Ice Age*, J. Geikie, chs. xxix, xxx, 1894.

have discussed in the British lowlands. That Scandinavia was at one time almost wholly buried beneath snow and ice is indubitable; it is equally so that at the outset the land stood above its present level, and that during the later stages of the Glacial Epoch parts, at any rate of Southern Norway, had sunk down to a maximum depth of 800 feet. In Germany, however, erratics are scattered over its plain and stranded on the slopes of the Harz and Riesengebirge up to about 1400 feet above sea-level. The glacial drifts of the lowlands sometimes contain dislodged masses of neighbouring rocks like those at Cromer, and we read of other indications of ice action. I must, however, observe that since the glacial deposits of Möen, Warnemünde, and Rügen often present not only close resemblances to those of our eastern counties but also very similar difficulties, it is not permissible to quote the one in support of the other, seeing that the origin of each is equally dubious. Given a sufficient 'head' of ice in northern regions, it might be possible to transfer the remains of organisms from the bed of the Irish Sea to Moel Tryfaen, Macclesfield, and Gloppa; but at the last-named, if not at the others, we must assume the existence of steadily alternating currents in the lakes in order to explain the corresponding bedding of the deposit. This, however, is not the only difficulty. The 'Irish Sea glacier' is supposed to have been composed of streams from Ireland, South-West Scotland, and the Lake District, of which the second furnished the dominant contingent; the first-named not producing any direct effect on the western coast of Great Britain, and the third being made to feel its inferiority and "shouldered in upon the mainland". But even if this ever happened, ought not the Welsh ice to have joined issue with the invaders a good many miles to the north of its own coast? Welsh boulders at any rate are common near the summit of Moel Tryfaen, and I have no hesitation in saying that the pebbles of riebeckite-rock, far from rare in its drifts, come from Mynydd Mawr, hardly half a league to the E.S.E., and not from Ailsa Crag.

. . . .

During the last few years, however, the lake-hypothesis of Carvill Lewis has been revived under a rather different form by some English advocates of land-ice. For instance, the former presence of ice-dammed lakes is supposed to be indicated in the upper parts of the Cleveland Hills by certain overflow channels. I may be allowed to observe that, though this view is the outcome of much acute observation and reasoning,[1] it is wholly dependent upon the ice-barriers already mentioned, and that if they dissolve before the dry light of sceptical criticism the lakes will "leave not a rack behind". I must also confess that to my eyes the so-called 'overflow channels' much more closely resemble the remnants of ancient valley-systems, formed by only moderately rapid rivers, which have been isolated by the trespass of younger and more energetic streams, and they suggest that the main features of this picturesque upland were developed before rather than after the beginning of the Glacial Epoch. I think that even 'Lake Pickering', though it has become an accepted fact with

[1] P. F. Kendall, Quart. Journ. Geol. Soc., vol. lviii, p. 471, 1902.

several geologists of high repute, can be more simply explained as a two-branched 'valley of strike', formed on the Kimeridge Clay, the eastern arm of which was beheaded, even in pre-Glacial times, by the sea. As to Lake Oxford,[1] I must confess myself still more sceptical.

. . . .

The submergence hypothesis assumes that, at the beginning of the Glacial Epoch, our Islands stood rather above their present level, and during it gradually subsided, on the west to a greater extent than on the east, till at last the movement was reversed, and they returned nearly to their former position. During most of this time glaciers came down to the sea from the more mountainous islands, and in winter an ice-foot formed upon the shore. This, on becoming detached, carried away boulders, beach pebbles, and finer detritus. Great quantities of the last also were swept by swollen streams into the estuaries and spread over the sea-bed by coast currents, settling down especially in the quiet depths of submerged valleys. Shore-ice in Arctic regions, as Colonel H. W. Feilden[2] has described, can striate stones and even the rock beneath it, and is able, on a subsiding area, gradually to push boulders up to a higher level. In fact, the state of the British region in those ages would not have been unlike that still existing near the coasts of the Barents and Kara Seas. Over the submerged region southward, and in some cases more or less eastward, currents would be prevalent; though changes of wind would often affect the drift of the floating ice-rafts. But though the submergence hypothesis is obviously free from the serious difficulties which have been indicated in discussing the other one, gives a simple explanation of the presence of marine organisms, and accords with what can be proved to have occurred in Norway, Waigatz Island, Novaia Zemlya, on the Lower St. Lawrence, in Grinnell Land, and elsewhere, it undoubtedly involves others. One of them—the absence of shore terraces, caves, or other sea marks—is perhaps hardly so grave as is often thought to be.

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But other difficulties are far more grave. The thickness of the Chalky Boulder-clay alone, as has been stated, not unfrequently exceeds 100 feet, and, though often much less, may have been reduced by denudation. This is an enormous amount to have been transported and distributed by floating ice. The materials also are not much more easily accounted for by this than by the other hypothesis. A continuous supply of well-worn chalk pebbles might indeed be kept up from a gradually rising or sinking beach, but it is difficult to see how, until the land had subsided for at least 200 feet, the Chalky Boulder-clay could be deposited in some of the East Anglian valleys or on the Leicestershire hills. That depression, however, would seriously diminish the area of exposed chalk in Lincolnshire and Yorkshire, and the double of it would almost drown that rock. Again, the East Anglian Boulder-clay, as we have said, frequently abounds in fragments and finer detritus from the Kimeridge and Oxford Clays.

[1] F. W. Harmer, Q.J.G.S., vol. lxii, p. 470, 1907.
[2] Q.J.G.S., vol. xxxiv, p. 556, 1878.

But a large part of their outcrop would disappear before the former submergence was completed. . . . The instances, also, of the transportation of boulders and smaller stones to higher levels, sometimes large in amount, as in the transference of 'brockram' from outcrops near the bed of the Eden Valley to the level of Stainmoor Gap, seem to be too numerous to be readily explained by the uplifting action of shore-ice in a subsiding area. Such a process is possible, but we should anticipate it would be rather exceptional.

Submergence also readily accounts for the above-named sands and gravels, but not quite so easily for their occurrence at such very different levels. . . . In other words, the sands and gravels, presumably (often certainly) mid-Glacial, mantle, like the Upper Boulder-clay, over great irregularities of the surface, and are sometimes found, as already stated, up to more than 1200 feet. Either of these deposits may have followed the sea-line upwards or downwards, but that explanation would almost compel us to suppose that the sand was deposited during the submergence and the upper clay during the emergence; so that, with the former material, the higher in position is the newer in time, and with the latter the reverse.

. . . .

The passing of the great Ice Age was not sudden, and glaciers may have lingered in our mountain regions when Palæolithic man hunted the mammoth in the valley of the Thames, or frequented the caves of Devon and Mendip. But of these times of transition before written history became possible, and of sundry interesting topics connected with the Ice Age itself—of its cause, date, and duration, whether it was persistent or interrupted by warmer episodes, and, if so, by what number, of how often it had already recurred in the history of the earth—I must, for obvious reasons, refrain from speaking, and content myself with having endeavoured to place before you the facts of which, in my opinion, we must take account in reconstructing the physical geography of Western Europe, and especially of our own country, during the Age of Ice.

Not unnaturally you will expect a decision in favour of one or the other litigant after this long summing up. But I can only say that, in regard to the British Isles, the difficulties in either hypothesis appear so great that, while I consider those in the 'land-ice' hypothesis to be the more serious, I cannot, as yet, declare the other one to be satisfactorily established, and I think we shall be wiser in working on in the hope of clearing up some of the perplexities. I may add that, for these purposes, regions like the northern coasts of Russia and Siberia appear to me more promising than those in closer proximity to the North or South Magnetic Poles. This may seem a "lame and impotent conclusion" to so long a disquisition, but there are stages in the development of a scientific idea when the best service we can do it is by attempting to separate facts from fancies, by demanding that difficulties should be frankly faced instead of being severely ignored, by insisting that the giving of a name cannot convert the imaginary into the real, and by remembering that if hypotheses yet on their trial are treated as axioms, the result will often bring disaster, like building a tower on a foundation of sand. To scrutinize, rather than to advocate any hypothesis, has been my aim throughout this address, and, if my efforts have been to some extent successful, I trust to be forgiven, though I may have trespassed on your patience and disappointed a legitimate expectation.

II.—Index Generum et Specierum Animalium. Report of a Committee consisting of Dr. Henry Woodward (Chairman), Dr. F. A. Bather (Secretary), Dr. P. L. Sclater, Rev. T. R. R. Stebbing, Dr. W. E. Hoyle, Hon. Walter Rothschild, and Lord Walsingham.[1]

CONTINUOUS and steady progress has been made by Mr. Davies Sherborn in the preparation of Volume II of this Index. Since the report for last year was sent in, Mr. Sherborn has dealt with the remainder of the separate works of authors whose names begin with C, and of these the various editions of Cuvier proved exceptionally long and tedious to analyse. Other works have also been dealt with as opportunity offered.

Valuable assistance has been rendered by Mr. Hartley Durrant, who lent from Lord Walsingham's library (presented to the Trustees of the British Museum) a fine copy of the extremely rare work by Billberg, *Enumeratio Insectorum*, 1820, which has been indexed and made available for reference.

The slips, which are preserved in the British Museum (Natural History) by the kindness of the Trustees, are quite in order for those who wish to consult them, and are of exceptional value to anyone monographing a particular genus.

Mr. Sherborn and Mr. H. O. N. Shaw have written a paper clearing up the difficulties surrounding Sowerby's *Conchological Illustrations* and Gray's *Descriptive Catalogue of Shells*,[2] and Mr. Sherborn himself has written on the dates of the parts of Burmeister's *Genera Insectorum*, 1838–46.[3]

Systematic and regular work on this Index is greatly encouraged by the friendly attitude of the Association, and the Committee, in recommending its own reappointment, earnestly ask the Association to continue this valuable help by a further grant of £100.

III.—Outlines of the Geology of Northern Nigeria. By Dr. J. D. Falconer, M.A., F.G.S.[4]

THE Protectorate of Northern Nigeria lies for the most part between Lake Chad and the confluence of the Rivers Niger and Benue, and comprises an area of about 255,700 square miles. Crystalline rocks are exposed over about half of this area, and among them two series have been recognized: (1) a series of hard, banded, and much granitized gneisses of an Archæan type; (2) a series of quartzites,

[1] Read before the British Association Meeting, Sheffield, 1910 (Section D).
[2] Proc. Malac. Soc., September, 1909, pp. 331–40.
[3] Ann. Mag. Nat. Hist., January, 1910.
[4] Read before the British Association Meeting, Sheffield, 1910 (Section C).

phyllites, schists, and gneisses of sedimentary origin with associated amphibolites, hornblende schists, and other more or less metamorphosed igneous rocks. The two series, which were probably originally unconformable, have been folded together along axes which are predominantly meridional in direction. They have also been pierced by numerous igneous intrusions, which are readily subdivided into an older and a younger group. The older group consists principally of granites, wholly or partially foliated, which have been affected to a varying extent by the forces which produced the metamorphism of the gneisses and schists. The members of the younger group are non-foliated, and include such types as tourmaline granite, riebeckite granite, augite syenite, augite diorite, and numerous associated dyke rocks.

Rocks of Cretaceous age are found in the valleys of the Benue and the Gongola and in the angle between the two rivers. They are invariably gently folded and sometimes broken and faulted, and consist of a lower series of sandstones and grits, in part salt-bearing, and an upper series of limestones and shales, with numerous fossils of Turonian age. The post-Cretaceous rocks, which rest unconformably upon the Cretaceous Limestone, and are probably all of Eocene age, occur over three detached areas: (1) in Sokoto Province and the Niger Valley, (2) in Bauchi and Bornu, and (3) in Yola. The Sokoto Series, which contains marine intercalations yielding abundant Eocene fossils, is continuous southward with the sandstones, grits, and ironstones of the Niger Valley. The correlation of the sandstones, grits, and clays of Bauchi, Bornu, and Yola with the Eocene rocks of Sokoto and the Niger Valley is based partly upon lithological similarities and partly upon the absence of evidence of any extensive post-Eocene submergence of the Protectorate.

Extensive fields of basaltic lava occur in Southern Bornu and on the borders of Bauchi and Nassarawa; and numerous puys of trachyte, phonolite, olivine basalt, and nepheline basalt are distributed throughout Southern Bauchi, Muri, and Yola. The puys and lava-fields alike are the product of Tertiary volcanic activity.

During the latter part of the Tertiary period there appear to have been repeated minor oscillations of the crust, which culminated in the elevation of the Bauchi plateau and the Nassarawa tableland, the depression of the Chad area, and the establishment of the present river system.

IV.—The Occurrence of Marine Bands at Maltby. By Wm. H. Dyson.[1]

DURING the sinking operations at Maltby the writer has located the stratigraphical position of the fossils found and has inspected the excavated debris day by day. Although all fossils have been collected, reference is only here made to the marine bands.

Taking the top of the Barnsley Coal (2452 ft. 2 in. deep or

[1] Read before the British Association Meeting, Sheffield, 1910 (Section C).

2193 ft. 5 in. below Ordnance datum) as a base-line, the lowest marine band, 8 ft. 7 in. thick, occurred 340 ft. 1 in. above the Barnsley Coal, the section being 1 ft. 11 in. of bastard cannel overlain by 6 ft. 8 in. of blackish bind with balls of pyrites, and contained the following fossils, mostly preserved in pyrites: *Lingula mytiloides*, ? *Posidoniella*, *Pterinopecten carbonarius*, *P. papyraceus*, *Scaldia carbonaria*, *Euphemus urei*, *Macrocheilina* sp., *Glyphioceras* sp., *Cœlacanthus*, ? *Cheirodus*, *Megalichthys*, *Rhadinichthys monensis*, *Rhizodopsis sauroides*. Among these *Macrocheilina* was fairly abundant.

The next bed occurred 564 ft. 1 in. above the Barnsley Coal. The material was dark-blue bind with ironstone and small cank-balls, and the following forms were present: *Lingula mytiloides*, *Orbiculoidea nitida*, *Myalina compressa*, *Straparollus* sp., *Euphemus urei*, *Naticopsis* sp., *Pleuronautilus costatus*, *Solenocheilus cyclostoma*, *Acanthodes*, *Cladodus*, *Cœlacanthus*, *Megalichthys*, *Platysomus*, *Elonichthys* or *Acrolepis*, *Rhizodopsis*. Among these *Straparollus* is new to the Middle Coal-measures.

The next marine band, 20 ft. 0½ in. thick, lies 708 ft. 10½ in. above the Barnsley Coal, the section being 19 ft. 0½ in. of dark greyish-blue shale with hard cank-balls, resting on 12 inches of argillaceous limestone. It contains an abundant fauna, including twenty-six genera and thirty-five species of invertebrates, all marine forms. *Chonetes laguessiana*, *Lingula mytiloides*, *Orbiculoidea nitida*, *Productus anthrax*, *Ctenodonta lævirostris*, *Myalina compressa*, *Nucula æqualis*, *N. gibbosa*, *N. luciniformis*, *Nuculana acuta*, *Posidoniella lævis*, *P. sulcata*, *Pseudamusium anisotum*, *P. fibrillosum*, *Pterinopecten papyraceus*, *Scaldia carbonaria*, *Schizodus antiquus*, *Syncyclonema carboniferum*, *Euphemus d'orbignyi*, *E. urei*, *Loxonema acutum*, *L. ashtonense*, *L.* sp., *Rhaphistoma radians*, *Bellerophon* sp., ? *Dimorphoceras gilbertsoni*, *Ephippioceras clittellarium*, *Gastrioceras carbonarium*, ? *Glyphioceras paucilobum*, *G. phillipsi*, *G. reticulatum*, *G.* sp., *Orthoceras asciculare*, *O. sulcatum* = *koninckianum*, *O.* sp., *Pleuronautilus costatus*, *Acanthodes*, *Cœlacanthus*, *Elonichthys*, *Listracanthus*, *Megalichthys*, *Platysomus*, *Rhizodopsis sauroides*. Among these *Pseudamusium anisotum* has not hitherto been found above the Carboniferous Limestone. Among the fish-remains *Listracanthus* should be noted.

The highest bed occurs 1000 feet below the summit of the Middle Coal-measures and 1244½ feet above the Barnsley Coal. It is 10 ft. 11 in. thick, consisting of grey bind with ironstone bands, of greasy appearance. The fauna is poor, but Goniatites are not uncommon. *Lingula mytiloides*, *Orbiculoidea nitida*, *Myalina compressa*, *Nuculana acuta*, ? *Bellerophon* sp., *Glyphioceras phillipsi*, *G.* sp., *Orthoceras* sp., *Listracanthus*, *Megalichthys*, *Rhadinichthys monensis*. Among the fish-remains *Listracanthus* is to be recorded.

The writer is indebted to Dr. Wheelton Hind, F.G.S., and Dr. A. Smith Woodward, F.R.S., for examining and naming the fossils.

REVIEWS.

I.—Monograph of the Okapi—Atlas. By Sir E. Ray Lankester, K.C.B., M.A., D.Sc., F.R.S. Compiled with the assistance of W. G. Ridewood, D.Sc. 48 plates. 4to. Printed by order of the Trustees. Price 25*s*.

SINCE its discovery some ten years ago, the Okapi has perhaps been the subject of more papers and memoirs than have ever been devoted to any Ungulate mammal not of actual economic importance. The circumstances of its discovery, its isolation from other living forms, and its near relationship to *Palæotragus* and *Samotherium* of the Lower Pliocene of Greece have all excited general interest in it. An important addition to the publications referring to this animal has just been issued by the Trustees of the British Museum under the title *A Monograph of the Okapi—Atlas*. This volume consists of a series of forty-eight plates prepared under the direction of Sir E. Ray Lankester, in illustration of a complete account intended to be prepared by him. These illustrations are of especial value because they bring together figures of the skulls and skins of a considerable number of individuals, including not only those in the British Museum, but also several from foreign museums and private collections. One set of plates consists of a beautiful series of drawings of the skulls of a number of individuals, illustrating the great variability of this part of the skeleton and of the degree of ossification of the curious separate horn-cores or ossicones, which in one set of individuals are entirely absent. A number of other plates show some of the remarkable peculiarities in the structure of the vertebræ, particularly in the cervical region, and finally some ten plates are devoted to demonstrating the extreme variability of the striping on the fore and hind legs, and incidentally prove the futility of naming new species on the evidence of such unstable characters. It is much to be regretted that, according to the preface, the volume of text relating to these plates will probably not be published: at the same time the recent publication of several important memoirs on the subject renders this omission less serious, and the detailed and careful descriptions of the plates prepared by Dr. W. G. Ridewood add greatly to the value of the volume and go far to reconcile us to the absence of the text. The plates are for the most part drawn by Miss G. M. Woodward and Mr. Grönvald.

II.—Æolian Deposits.

[Alexandra Ivchenko's papers (in Russian, with abstract in French) will be found, illustrated, in Khrishtafovich's *Ezheiodnika no Gheol. i Min. Rossii* (*Ann. géol. et min. Russie*), xii, pp. 146–70, 1909.]

A GOOD deal has been written lately on Deserts in one form or another, and we think it may be interesting to give a résumé of the views of Alexandra Ivchenko (or as he transliterates his name into French, Iwtschenko) of Kiev. Mr. Ivchenko finds that the types of stratification in æolian deposits can be divided into 'barkhans',[1] ripple-mark, diagonal with opposed dips, discordant parallelism with great differences in the dips, horizontal and vertical. These types occur both in sandy and dusty accumulations. One can observe in purely æolian deposits, strata due to insulation (limy, saline, or irony), to vegetation (earthy, clayey), or to wind; and these can be further subdivided. One can trace certain characteristics as one passes from the desert type of deposits to that of the edge of the desert and from that to the steppe. The loess of Turkestan is purely æolian, while that of Kiev is aquatic. Similarly, one can judge how different beds of other geological ages were formed; thus the red grits of Tartarian age were æolian, while the sands bordering the Dnieper were aquatic. It is necessary to distinguish the dusts of deserts formed from the denudation of local rocks from that formed from the denudation of the soils in depressions. In addition to ordinary winds the action of whirlwinds can often be distinguished by the spiral or circular arrangement of the dust particles. Whirlwinds, too, have a certain influence in the formation of desert depressions. Gentle breezes blowing towards ridges do not seem to have much influence in elevating dust unless the escarpment is below 30. Erosion and denudation of accumulations of dust upon low slopes seem to be localized and do not have a general influence. The dimensions of particles of desert dust transported by the wind diminish from the centre towards the margins of the desert: the dimensions of the dust of the soil, which are less mobile and less carried, diminish from the margins to the centre. The grains of sand have special characters in æolian and in aquatic deposits; in the former they are characteristically triangular. The vertical separation of accumulations of dust or sand can, up to a certain point, be attributed to the existence of vertical stratification. Similar beds due to the resistance of wind pressure may be in part the result of pressure of the upper beds on the lower beds of such deposits. The first (due to resistance to the pressure of the wind) form the surface of the accumulation, and the second (due to compression) form the interior.

III.—Brief Notices.

1. "Les Cavernes et les Rivières souterraines de la Belgique" is the title of a sumptuously illustrated work by E. van den Broeck, E. A. Martel, and E. Rahir, which has been published at Brussels in two volumes, 1910, illustrated by 26 plates and 435 text-figures. There is a total of 1857 pages, arranged in an extraordinary manner, as there are sundry interpolations independently paged in successive places in each volume, so that precise reference is rendered difficult.

The subject is dealt with in special relation to the hydrology of the Devonian and Carboniferous Limestones, and the question of potable waters.

The great purity of the Givetian Limestone in the Devonian and of the Upper Visean Limestone in the Carboniferous has facilitated the corrosive action of water and led to the production of some of the more

[1] Semicircular continental dunes.

important caverns and subterranean watercourses. These features are to some extent naturally dependent on tectonic structure, but all points are duly discussed—the folds and fractures, the mineral composition of the limestones and dolomites, the organic remains, notably of coral and crinoid, and the various kinds of weathering. The different forms of caverns and grottoes, the stalactites and stalagmites, tufa, swallow-holes, and underground channels are fully described; and the whole subject is illustrated by pictorial views and many charming vignettes, by diagrams, plans, geological maps, and geological sections. The living fauna and flora as well as Pleistocene and later organic remains receive attention, and there are abundant references to the literature.

2. The "Cenozoic Mammal Horizons of Western North America" are dealt with by Professor H. F. Osborn (Bulletin 361, U.S. Geol. Survey), and Mr. W. D. Matthew contributes an appendix comprising faunal lists of the Tertiary mammalia of the West. Various mammalian zones are recognized, from the *Polymastodon* zone of the basal Eocene to the *Equus* zone of the Pleistocene; and Professor Osborn concludes "that North America promises to give us a nearly complete and unbroken history of the Tertiary in certain ancient regions, which are, after all, comparatively restricted".

3. A "Description of New Carnivores from the Miocene of Western Nebraska" has been contributed by Mr. O. A. Peters to the Memoirs of the Carnegie Museum, Pittsburg, vol. iv, No. 5 (undated). The forms include species of *Daphænodon*, *Borocyon*, *Cynodesmus*, and *Tephrocyon*, belonging to the Canidæ; and *Paroligobunis*, belonging to the Mustelidæ.

4. We have received the first part of a work entitled "Geologische Charakterbilder", edited by Dr. H. Stille, and comprising six beautiful illustrations, with descriptions, by E. Philippi, of "Eisberge und Inlandeis in der Antarcktis" (Berlin, 1910).

5. "Geology in relation to Civil Engineering," by Mr. Robert Boyle, Assoc.M.Inst.C.E., President of the Glasgow University Geological Society, has been published by John Smith & Co., Glasgow, price 1*s*. It is a small work of 19 quarto pages, and contains brief practical suggestions on the relation between geology and constructive works such as roads, railways, bridges, docks, etc., as well as on water-supply. As the author remarks, "Success or failure in an engineering scheme depends largely on geological conditions." General remarks are also given on geology, field-work, and the use of maps and sections; but it may be observed that it is not often that the geologist has to work out the true dip of strata by trigonometrical methods. The author devotes more space than appears necessary to igneous rocks and petrology, illustrating the subjects of road-metal, building-stone, etc., by microscopic sections. These are matters that few engineers can deal with personally, and the advice of a specialist should be sought when necessary.

6. Liverpool Geological Society.—In commemoration of the Jubilee of this Society, a small but interesting volume, *A Retrospect of*

Fifty Years' Existence and Work, has been prepared by a former President, Mr. W. Hewitt, B.Sc. (Liverpool, C. Tinling & Co., 1910, pp. 117). The Society was founded on December 13, 1859, at a meeting held at the residence of G. H. Morton. An excellent portrait of him is given, and there are portraits also of C. Ricketts, T. Mellard Reade, and Joseph Lomas, as well as illustrations of the footprints of *Cheirotherium* and of the gypsum boulder of Great Crosby. An account of the work accomplished by the Society, a list of papers published in the Proceedings, and biographical notices of some past members are included in the volume.

7. Cotteswold Naturalists' Field Club.—The first part of vol. xvii of the Proceedings of this Club is sumptuously illustrated with twenty-one plates and a number of text-figures. Geological articles dominate. Among these is a sketch of "Some Glacial Features in Wales and probably in the Cotteswold Hills", by Mr. L. Richardson, who gives an account of the prominent glacial phenomena in the region of Snowdon, and draws attention to glacial features in the Brecon Beacons and in the amphitheatral hollows of the Cotteswolds. The Rev. H. H. Winwood records a section of the White Lias (Upper Rhætic) at Saltford, near Bath. Mr. Richardson further contributes a detailed account of "The Inferior Oolite and Contiguous Deposits of the South Cotteswolds".

8. "The Volcanic Rocks of Victoria" formed the subject of the presidential address delivered by Professor E. W. Skeats in 1909 to Section C (Geology and Mineralogy) of the Australian Association for the Advancement of Science.

9. Geological Survey of the Transvaal.—"The Geology of the Country round Zeerust and Mafeking," by Mr. A. L. Hall and Dr. W. A. Humphrey, 1910, is the title of an explanation of Sheets 5 and 6 of the Survey Map of the Transvaal. The geological formations belong to the Dolomite and Pretoria Series, with intrusive and contemporaneous igneous rocks. The structure of the region, the drainage and water-supply, the Malmani goldfield, and the lead and zinc deposits of the Marico are described.

10. A Wealden *Anodonta*.—In 1856 Beckles referred to "*Anodon*(?)" in his paper "On the Lowest Strata of the Cliffs at Hastings" (Q.J.G.S., vol. xii, 1856, pp. 291, 292), a mixture of shells some of which are obviously Unios. Mr. R. B. Newton (Proc. Malac. Soc., vol. ix, June, 1910, pt. ii, p. 114) has now gone carefully into the subject and finds that an undoubted *Anodonta* does occur in the Wealden beds along with the various Unios so often met with. He figures and describes a beautiful specimen of the fossil, which he calls *A. Becklesi*, from the Fairlight Clays of Hastings. This forms part of the Rufford Collection now in the British Museum, and seems to be the oldest known true *Anodonta* yet described.

11. Geological Survey of Egypt.—A Report on "The Building Stones of Cairo Neighbourhood and Upper Egypt", by Dr. W. F. Hume, Director, is issued as *Survey Department Paper*, No. 16, 1910. It comprises full particulars of the white and yellow nummulitic

limestones that are quarried at Gebel Moqattam to the south-east of Cairo and elsewhere; some detailed quarry records are given on the authority of the late T. Barron, and a report on the chalky nummulitic limestones used as building stone in Upper Egypt is contributed by Mr. H. J. L. Beadnell. There are also notes on sand-lime bricks, portland cement, etc.

CORRESPONDENCE.

ORIGIN OF THE BRITISH TRIAS.

Sir,—In the October number of this Magazine Mr. A. R. Horwood has given us a summary of the conclusions he has come to as a result of his researches into the origin of the British Trias. The paper as printed, being only an abstract of a longer paper read at the British Association, has no doubt suffered much in clearness as a result of condensation. In its present form, however, it is unsatisfactory, being composed in part of facts long known and now put forward none too clearly and by no means for the first time, and in part of more or less new statements requiring substantiation. I feel, and I daresay I voice the feelings of other readers too, that I should now like to hear the evidence on which some of these last-mentioned statements are based. I do not wish for the present to be understood as criticizing the conclusions, but merely as asking for a more explicit statement of the facts. I will take the points under Mr. Horwood's own numbers.

(3) If there is a general absence of delta bedding in the Bunter [see (9)], what then is the evidence that it is a delta? Is it its dactyloid form (6), and, if so, is this capable of being demonstrated on a map?

(9) Apart from the fact that beds which should theoretically have lain at 40° now lie horizontal, is there any other evidence of tilting through an angle of 45° in any part of the Trias?

(16) I am not very clear as to the author's meaning here, but I presume it is that the signs of wind erosion are confined to one level on the syenites and other older rocks. I would now ask how many cases of this wind erosion are known and to what extent they can be demonstrated to occur only at one horizon in the marls; also whether the opportunities for their observation are not very exceptional?

(20) What is the evidence that the supposed Bunter river came from North-West Scotland? I am aware that I may be displaying great ignorance of the literature of the subject in asking this question, but in that case a reference will set me right.

(21) What are the points of petrographical correspondence between the Bunter, Keuper, and modern delta formations? What bearing on this question has the immediately following statement that "the Leicestershire Trias shows signs of chemical action, the Nile delta of mechanical"?

W. B. Wright.

Dublin.

POLLICIPES FROM THE TRIMMINGHAM CHALK: A CORRECTION.

In the GEOLOGICAL MAGAZINE for August, 1906, I described a number of species of Cirripedes mostly from the Norfolk coast. Amongst these I recorded and figured two valves from Mr. Brydone's Collection (op. cit., p. 348) under the name of *Pollicipes concinna*. The specific name *P. concinnus* was used by Darwin more than fifty years previously in his Monograph on the fossil Lepadidæ (Pal. Soc., 1851, p. 50, pl. iii, fig. 1) for an Oxford Clay species. I regret my carelessness, and apologize for having neglected to correct it earlier.

I now propose to designate these specimens from the Trimmingham Chalk Bluff as *Pollicipes corrugatus*.

HENRY WOODWARD.

OBITUARY.

JOHN WILLIS CLARK, M.A., F.S.A.

BORN JUNE 24, 1833. DIED OCTOBER 10, 1910.

WE regret to record the death of Mr. J. W. Clark, Registrar of the University of Cambridge, and formerly Superintendent of the University Museum of Zoology and Comparative Anatomy. A versatile man who rendered distinguished service to Art, Literature, and Science, Mr. Clark was endowed with a personality that brought him many friends. To geologists he was known as chief author (with Professor T. McKenny Hughes) of the fascinating *Life and Letters of the Reverend Adam Sedgwick* (2 vols., 1890); and as he remarked in the preface, "No task could have been more congenial to me."

MISCELLANEOUS.

NORWICH CASTLE MUSEUM: NEW CURATOR APPOINTED.—In March last (GEOL. MAG., pp. 141–3) we noticed this excellent Museum and made special reference to its Curator, Mr. James Reeve, F.G.S., who had held office for more than fifty years, and sought retirement. Mr. Reeve was appointed "Consulting Curator of the Museum", and the salary of Mr. Frank Leney, the Assistant Curator, was raised, but the post of Curator was not filled up at that time. On September 21 the Council met under the presidency of the Lord Mayor, who moved that, as recommended by the Castle Museum Committee, Mr. Frank Leney, the present Assistant Curator, be appointed Curator, at an annual salary of £250. The Lord Mayor, who was seconded by Mr. Wild, said the Committee were unanimous in this recommendation. Mr. Leney had held the post of Assistant Curator for ten years, and they were all agreed that it was for the benefit of the city and of the museum that the appointment should be made. The motion was then carried *nem. con.*

Award of the Keith Gold Medal of the Royal Society of Edinburgh to Dr. Wheelton Hind, F.R.C.S., F.G.S.—At a meeting of the Royal Society of Edinburgh on July 18 last, under the presidency of Dr. R. H. Traquair, the Keith Gold Medal was presented to Dr. Wheelton Hind for a paper on "The Lamellibranch and Gasteropod Fauna of the Millstone Grit of Scotland". The fossils, said Dr. Traquair, forming the subject of this research were placed in the hands of Dr. Hind for determination by the Geological Survey. They were found by Mr. Tait in certain marine bands in the basal portion of the Millstone Grit, charged with Lamellibranchs, Brachiopods, and Gasteropods, and associated with Lower Carboniferous species of plants. They have been collected from the counties of Midlothian, West Lothian, Lanark, and Stirling, their horizon being not far below the line which has been drawn between the Upper and Lower Carboniferous floras in accordance with the determinations of Dr. Kidston. The remarkable feature of this research is the recognition in the Scottish collection of a Lamellibranch fauna, of which quite 50 per cent. of the species are new to Europe, and which closely resembles the Lamellibranch fauna of the Coal-measures of Nebraska and Illinois in North America. The most striking member of the fauna is the shell *Prothyris elegans*, Meek, this being the first occurrence of the genus in the Carboniferous rocks of Great Britain. Dr. Hind's researches show that it is impossible to distinguish any characters sufficient to separate the Scottish and American species from each other. He has demonstrated that the Gasteropods in this collection bear a strong relation to those of North America, several species being regarded as identical. He has also noted that the Brachiopods belong to a late period of Carboniferous time. In addition to his valuable researches in the Molluscan fauna of the Carboniferous Series in Great Britain, Dr. Wheelton Hind, who has been a Volunteer officer for many years, was two years since asked to raise a Battery of heavy artillery for the Territorials. This he succeeded in doing, and under command of Major Wheelton Hind on Dartmoor his company this year carried off the King's prize for heavy batteries, both for firing and drill.

Swiney Lectures on Geology.—A course of twelve lectures will be delivered by T. J. Jehu, M.A., M.D., F.R.S.E., on the Coasts of Great Britain and Ireland, in the Lecture Theatre of the Victoria and Albert Museum, South Kensington, on Mondays and Tuesdays at 5 p.m. and Saturdays at 3 p.m., beginning on Saturday, November 5, at 3 o'clock. The lectures will be illustrated by lantern slides, and admission to the course will be *free*. Lecture I. Introductory. II. Recent Changes in the Relative Levels of Land and Sea. III. Movements of the Sea—The Foreshore. IV. The Coastline. V. Erosion and Accretion. VI. Sands and Sand-dunes. VII. The Fauna and Flora of the Coastline. VIII. The Coast of Scotland. IX. The East Coast of England (Tweed to Thames). X. The South Coast of England (Thames to Cornwall). XI. The Coast of the West of England and Wales. XII. The Coast of Ireland.

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DECEMBER, 1910.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VII.

No. XII.—DECEMBER, 1910.

ORIGINAL ARTICLES.

I.—The Relation between the Foliated and non-Foliated Rocks of Southern Nigeria, West Coast, Africa.

By John Parkinson, M.A., F.G.S.

A CONTRIBUTION by Messrs. Horwood & Wade[1] to the Geological Magazine for November, 1909, calls attention (p. 505) to certain papers by me on the relation between the gneisses and schists and the later granites of Southern Nigeria.

Since these papers were published in 1907 I have had the opportunity of visiting the western parts of Liberia, a considerable proportion of the littoral of the Gold Coast Colony, and on two occasions have spent some time in Southern Nigeria. These expeditions have served to impress upon me the close resemblance existing between the crystalline rocks of these widely scattered regions, a resemblance so marked as to suggest a common origin. The following notes on the petrology of the Oban Hills in Southern Nigeria may throw some light on the relation between the schists, the gneisses, and the granites of this part of West Africa.

A study of the crystalline axis of the Oban Hills shows that, while the rocks may be conveniently grouped under certain heads, yet this arrangement must remain largely an artificial one. Acid orthogneisses occupy by far the greater portion of the central part of the area, and are, as it were, represented or replaced by a number of granite bosses westward in the neighbourhood of the Iyangita, an important tributary of the Calabar River. A short investigation shows that the gneisses include a variety of types, the mutual relations of which prove that they differ in age the one from the other to at least some extent. I have grouped these together into a single series: firstly, on account of their general petrographical similarity; secondly, on account of similarity in habit, e.g. the frequent occurrence of a streaky or of a banded structure; and, thirdly, on account of the occurrence of special but widely distributed petrological types, e.g. a garnet-granulite.

In addition, comparison of a suite of specimens in the field shows that rocks petrographically granites pass by insensible gradations into these gneisses. Whatever the agent which produced the foliation in the one, it was clearly non-operative during the solidification of

[1] "The Old Granites of Africa."

that part of the series represented by the other. In some localities no hard and fast line can be drawn between a series of specimens which, taken individually, exhibit many differences, and which have been collected over a distance to be measured only by a few yards. Distinctly later, though the difference in age need not, geologically, be very great, are the granites of the Iyangita, of Itara, and numerous other localities, where now and again we may see these rocks clearly intrusive into the Gneissose Series. To work back a stage in the geological sequence we must appeal to the schists of the Calabar River at the Ekankpa Ford, south-east of Isbofia, of the Kwa River at Abuton, and of the Akpa Iyefe.[1] In each locality (and the three given could be supplemented by others from the eastern and north-eastern parts of the hills) is a well-marked group of mica- and hornblende-schists, associated with granulites, and riddled by acid intrusions. In the first and second a banded gneiss is produced by a kind of *lit-par-lit* injection; in the last the dissemination of the acid magma was irregular. In regard to the nature of the intrusions, the first is now a granitic gneiss; the second a granitic gneiss associated with a coarser rock of pegmatoidal habit; in the third, the rock is practically a pegmatite. To these petrographical types the remainder of the district affords many resemblances, amounting often to identities. Pegmatites crushed and uncrushed are distributed sporadically, but far from uncommonly, over the entire area, carrying tourmaline, garnet, and muscovite as accessory minerals; here and there, e.g. near Netim, Awi, Aking, Awöfong, and Mkpot, mica- and hornblende-schists appear, petrographically to be correlated with those of Abuton and the Akpa Iyefe.

The typical *mica-schists* of the Akpa Iyefe on the Kamerun frontier are rather massive rocks, not conspicuously laminated, and with a tendency to become gneissose. On applying a low-power hand-lens quartz and felspar become apparent, although crystals of either mineral are here and there discernible to the naked eye. In some specimens an indication of banding is noticeable. The attempt at a gneissose structure in the schists is obvious in many places, and is of interest in relation to the very close association they have to the intrusive granite. Possibly the structure is due to material which permeated from the acid magma, as I have suggested elsewhere[2] in referring to the work of Lacroix and others.

In two instances clear evidence is obtained of partial liquefaction and incorporation of a micaceous schist by a rock of granitic composition. The first of these is from a creek above the Falls of the Akpa Iyefe; the second a gneissic band in the very similar mica-schists of the river bed above Mkpot. In slides prepared from these rocks can be studied the partial solution of felspar, muscovite, and biotite by an agent which generally is felspar, but occasionally quartz.

In the Mkpot example blunt tongues of felspar (apparently albite) frequently containing *quartz vermiculé* have forced their way through the edges of the original porphyritic orthoclases of the younger rock.

[1] See outline map of the Oban Hills, Q.J.G.S., vol. lxiii, p. 314, 1907.
[2] Q.J.G.S., vol. lvi, p. 316, 1900.

This is a fine-grained porphyritic biotite-gneiss. The microscopical character of the mica-schists of the lower reaches of the Akpa Iyefe need be but briefly described. One of the most typical examples taken from about half a mile below the Falls is distinguished by the abundance of a reddish-brown and reddish-yellow mica. The mineral forms exceedingly irregular and tattered flakes, which are always small. Less common than this biotite, and associated with it, are crystals of muscovite. Quartz and an acid plagioclase build up the greater part of the rock.

Other specimens contain nearly equal quantities of biotite and hornblende. Quartz is locally very abundant; the plagioclase may be of rather a basic variety; sphene and apatite are accessory minerals.

The pegmatoid granites associated with the mica-schists of the Akpa Iyefe are a well-marked group. The clearly intrusive nature of these rocks and the closeness of their relations to the schists, the one succeeding to the other without sign of chilled edges and with the utmost irregularity, make them of some interest. Their texture varies considerably; some coarse varieties, forming ill-defined veins, are remarkable for their large pink orthoclases and lump-like masses of quartz having a pegmatoid habit. Doubtless they differ slightly in date of intrusion. Small brownish-red garnets, plates of muscovite occasionally about an inch across, and, not least important, small nests and crystals of black tourmaline are usual accessories. Biotite is found occasionally, but rarely in quantity. Except some aplite dykes, these coarse varieties appear to be the youngest members of the series, and form irregular veins in a finer-grained rock of essentially the same composition and appearance.

The mica-schists of the Kwa River in the neighbourhood of the Falls below Abuton are usually reddish-brown close-textured rocks, remarkably well foliated. The mica is by far the most conspicuous mineral. In other specimens the rocks are very massive, brownish-black in colour, and speckled with crystals of felspar. Now and again hornblende-schists occur sparingly. Characteristic of the neighbourhood is the occurrence of a tourmaline-bearing garnetiferous gneiss, which is associated with the schists so closely as to produce a beautifully banded rock by a process apparently of *lit-par-lit* injection.[1] This banding is sometimes on a broad scale and not very clear, and at others finer and exceedingly regular. Now and then the two rocks interlock in wedge-like forms, while the intrusive nature of the more acid is shown by the presence of fragments of the schists, more or less disintegrated, contained by it.

The Gneisses.—Descriptions of a few sections at and between the villages of Netim and Ibum on the western side of the Oban Hills will serve to show the nature of the gneiss of the country.

At the first stream north of Netim on the Netim-Ibum path the oldest rock is a biotite-hornblende-schist rich in the ferromagnesian minerals, and containing some quantity of a yellowish-green constituent, probably epidote. This passes into a biotite-gneiss, or,

[1] Compare G. A. J. Cole on the production of banded gneisses by the incorporation of sedimentary and igneous material by an invading granitic magma ("Marginal Phenomena of Granite Domes": Rep. Brit. Assoc., 1905).

I believe, more accurately, the latter is intrusive. In places this is almost a granite, and is characterized by porphyritic crystals of orthoclase, half an inch or so in length, often retaining their rectangular outlines. Now and again these rocks are cut by a second gneiss, also containing biotite, though not in great quantity, and distinguished from the first by containing no phenocrysts and by being on the whole of finer texture. Distinct in certain localities, no hard and fast line probably exists in reality between the two. A differentiation obvious in one place had not apparently taken place in another.

Associated with these rocks, and clearly later in date than they, are masses and veins of a coarse pegmatite (the crystals of pink orthoclase may be a couple of inches in length), and here and there aplite veins still later in date cut through the whole.

To avoid misconception it should be stated that, in this locality, the biotite-hornblende-schist above mentioned exists only as fragments, and not in well-defined exposures free from acid intrusions. The evidence rests on lenticular bands and inclusions with torn and frayed-out edges passing more or less rapidly into the surrounding gneiss.

In such a series it is useless to expect constant lithological types, and the country between Netim and Ibum, a distance of 24 miles, provides examples to show that every gradation exists between the rocks above mentioned. The principal points are born out by the excellent exposures of rock on the Calabar River and on an important tributary joining the main stream where it is crossed by the Ibum Path, a few miles south of that village. Near the path a biotite-granite is the predominant rock, but higher up the main stream irregular fragments of a fine micaceous gneiss or schist are contained in a gneiss of more acid composition. The biotite in the former rock forms minute flakes, and the quartz and felspar cannot be differentiated by the naked eye. Later than either is a coarse quartz-orthoclase-plagioclase rock, some of the quartz grains being nearly a quarter of an inch in length. This is a pegmatite.

Examination of thin sections shows that in the micaceous gneiss or schist reddish-brown flakes of biotite are the only coloured constituent, with the exception of a few grains of an iron oxide and some small garnets. The felspars are represented by microcline, orthoclase, and an acid plagioclase, quartz is rather less abundant than the felspars, and exhibits crush shadows. The structure of the rock is granulitic, and *quartz de corrosion* occurs here and there. The more acid gneiss consists almost entirely of quartz and of felspars of the same varieties as in the first instance. Lobed growths of *quartz vermiculé* in felspar are common. The rock differs but little from a granite.

Passing to the tributary stream above mentioned we find the irregular relation of basic to acid components giving place to a regular banded structure, occasionally well developed over a comparatively large surface of rock. Relation to the more irregular type is shown by the ends of a band tailing out into elongated wisps or streaks.

The rapid loss of foliation, by which the gneisses pass into granites, may be studied between the Calabar River and Ibum. The former rock contains angular inclusions, i.e. more basic patches, obliquely truncated by one more acid; these occur also as streaks and irregular bands. Comparison of a series of specimens taken from a distance of about four yards demonstrates a passage between granite and gneiss, the only differences being distinctness in foliation and banding of the mica; texture and bulk composition remaining the same.

The Granites.—Under this heading are placed all the later intrusive masses of acid composition, distinct from those grading into gneisses. They vary greatly in composition; doubtless they vary greatly in age.

One of the best-marked masses in the Oban Hills is the strikingly porphyritic rock of Itara. It is found near the word 'Huts' (in the map of 1903), to the north of the village of Ikuri, and extends southwards along the drainage basin of the Ukpong River, almost as far as Ibum. The rock is a biotite-granite, rich in quartz, and containing a multitude of crystals of pink orthoclase, occasionally a couple of inches in length. In a thin section the characteristic mica is of a yellowish-green colour; sphene and an epidote are common, and small crystals of apatite are not rare. The order of consolidation was apatite, sphene, epidote, biotite. Locally the rock is cut by aplite dykes. The typical granite of Ibum, near the headwaters of the Ukpong River, is a fine-grained, non-porphyritic rock containing sufficient biotite to give it a well-marked speckled appearance. Quartz is plentiful, and in places a suggestion of foliation may be noticed.

About 1½ miles north of the small river called 'Ndi 'Ncha, between Ibum and Netim, I found a small boss of a rather peculiar granite. The rock is of a medium degree of coarseness, characterized by blade-shaped and apparently homogeneous crystals of hornblende, scattered without orientation through the rock. Thin sections show these to consist of grains of green hornblende mingled with flakes of biotite. In some respects this rock, which has undergone a considerable amount of crush, is not quite a normal granite. Thus both ferromagnesian minerals enclose numerous grains of quartz or are greatly indented by them in a semi-poecilitic manner, the crystallization dates of the two minerals not being very different. Lobed outgrowths of felspar containing *quartz vermiculé* are also common. Microcline is absent, orthoclase predominates, although albite or oligoclase is abundant. Apatite is exceptionally plentiful, and one slide contains some interesting crystals and grains of white sphene.

The granite forming the left bank of the Calabar River, one quarter of a mile above Uwet (now being quarried by the Public Works Department), is of a grey-coloured uniform rock of medium texture, practically devoid of hornblende or mica. The rock is composed of almost equal proportions of quartz and felspar; the latter includes orthoclase, microcline, and an acid plagioclase. Numerous small flakes of muscovite and occasionally granules of impure calcite are developed in the felspar, the former not seldom in considerable quantity.

At 'Nsibimba, on the eastern side of the hills, is a very hard and massive biotite-granite containing rare garnets and muscovite; quartz and orthoclase are both abundant, and together build up practically the whole of the rock, for a triclinic felspar is exceedingly scarce. The rock has been only slightly modified by pressure.

The granite of Uwet differs considerably from the granites found between the Calabar River and the Iyangita in the neighbourhood of Uyanga and Ojo 'Nkorimba. The latter recalls the porphyritic granite of Itara in containing sphene as an important accessory constituent, and, in the presence of a mineral resembling epidote, certainly of primary origin, the identification being at present doubtful.

The rock from the Iyangita towards Iwudu contains some quantity of a strongly pleochroic green hornblende, and traces of the same mineral appear in the granite north of Ojo 'Nkorimba. Well-built crystals of brown biotite are conspicuous in all slides examined from this part of the district. Orthoclase is the predominant felspar; but the rock a short distance south of Uyanga contains large crystals of microcline, as does also a specimen collected between the Iyangita and Calabar Rivers. The plagioclases, commonly zoned, appear to be albite or oligoclase, or both. Large grains of quartz are plentiful, and *quartz vermiculé* is common and characteristic. In some specimens tourmaline occurs, but it is very rare. One or two of the rocks have been very slightly crushed.

The red aplites, which are apparently the latest igneous rocks of the lower Akpa Iyefe (for basalt dykes are not seen), consist of an aggregate of felspar and quartz, the former mineral slightly preponderating over the latter. Micropegmatite, the possible presence of which is suggested by the hand-specimen, is found to be but feebly represented; a thin, not very well defined rim of intergrowth is, however, usual where quartz and felspar meet. A point of some interest lies in the composite nature of the felspars; due, either to an almost complete resorption of an early generation of the mineral, or to a later influx of felspathic material which has partially dissolved the pre-existing mineral and embedded the fragments within its own substance.

Aplites also cut the porphyritic granite of Itara (along the valley of the Ukpong River). The same rocks, intrusive in hornblende-schists, are conspicuous in a creek running into the Agboyip River, itself a tributary of the Ukpong; and to the north of the village of Awi (south of Nsan), etc.

In distinguishing between the granitic gneisses and the later granites mention may be made of the fact that, as a systematic investigation of the alluvial deposits proves, monazite is characteristic of the former.

II.—On a Drift at Bostall Common, near Plumstead.

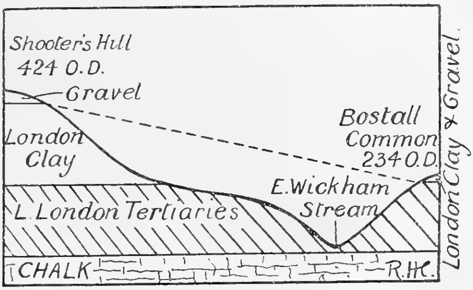
By R. H. Chandler.

CAPPING a small patch of London Clay on the highest part of Bostall Common (234 O.D.[1]), there is a 'drift' that presents peculiarities identical with part of the gravel on Shooters Hill (2 miles distant) at 424 O.D.[1]

The gravel at Shooters Hill has been frequently described, so

[1] Both these heights are the highest points of the drift.

need not be detailed here. It consists of a coarse, clayey gravel of rounded flint pebbles and beds of sand. Some of the pebbles are very much corroded outside, split into several pieces, and present curious coloured zonings.[1] Lower Greensand chert and quartz pebbles are rare, and quartzite pebbles very rare. A very characteristic feature is the presence of the above-mentioned corroded, split, and zoned pebbles. The rough cortex of the pebbles show knobs and pits as though partly decomposed by an acid, and for which no other word than 'corroded' seems applicable. The splitting may be along any axis, but is frequently parallel to the long one, and is not the usual frost shattering or pitting; a pebble may be found in three or four pieces and the pieces close together, as though the fracture were of recent origin. The zoning is also curious, and some pebbles show (on the split surfaces) several differently coloured concentric bands, evidently due to weathering and staining. An interesting point about these corroded and zoned pebbles is that the inner zone is frequently of an opaque cream colour, and is surrounded by brown, black, red, or other coloured translucent flint, and then comes the cream opaque cortex; whereas in ordinary weathered flint pebbles the translucent part is in the centre. These three points (i.e. corroding, splitting, and peculiar zoning) at once claim attention, and serve to give a characteristic feature to the gravel, and to distinguish it from the other 'Hill', or 'Terrace' gravels of the surrounding district.



Section from Shooters Hill to Bostall Common showing the relation of the 'drifts' and the erosion by the East Wickham stream. Horizontal scale 1 inch = 1 mile, vertical $\frac{1}{4}$ inch = 100 feet.

The Shooters Hill gravel rests on about 180 feet of London Clay and, as a recent section showed, Bagshot Sand in places.[2] The drift at Bostall Common caps the highest part of the Common, which consists of a circular patch of London Clay, about 100 yards in diameter and about 10 feet thick, and is separated from Shooters Hill by $1\frac{1}{2}$ miles of Blackheath, and Woolwich and Reading Beds (see Section). The gravel occurs as a thin sprinkling on the surface

[1] Mentioned by Dr. A. E. Salter from notes by Mr. A. L. Leach, *Woolwich Surveys*, 8vo, p. 19, Woolwich, 1909.
[2] A. L. Leach, Geol. Mag., Dec. V, Vol. VII, pp. 405–7.

of this small patch of London Clay, and agrees very closely in composition with the Shooters Hill gravel at a level of about 200 feet higher.

The extent of the spread of drift was revealed during the last two winters, when the top of the hill on Bostall Common was removed by the London County Council unemployed, and all the moderately large stones hand-picked and placed on one side. By looking over these heaps it was possible to form an accurate opinion of the composition of the drift, and it was then that the similarity to Shooters Hill gravel became so apparent. I have had the corroded, split, and zoned pebbles here in abundance, also two quartzite pebbles (this quartzite is curiously marked—precisely like one obtained from Shooters Hill), and a piece of the Lower Greensand Chert. Quartz pebbles I have not found, but as they would probably be small (as at Shooters Hill) they would not stand such a chance of being picked as the larger pebbles; this may account for their apparent absence.

The height of 234 O.D. is above any of the terraces associated with the Thames in this neighbourhood; moreover, the gravel is different from the Terrace gravels in that it contains no (or very few) subangular flints, no Bunter quartzite, Rhanella chert, or igneous rocks, all of which are plentiful in the terraces.

Mr. F. C. J. Spurrell has suggested[1] that this drift might be the remains of a Boulder Clay, or of its subjacent gravel, but considering its curious composition I suggest that it is more likely to have been derived as a 'trail' from the gravel on Shooters Hill, at a time when that mass of London Clay and its capping of gravel was much more extensive than at present. A reference to the sketch will show that this source of supply has been cut off for a long time; for the East Wickham stream, which rises on the slopes of Shooters Hill (as soakage from the gravel), and finds its way to the Thames at Plumstead, has now separated the patch of London Clay at Bostall Common from the mass of Shooters Hill by a valley 150 feet deep (in the line of section), and there has been uncovered an outcrop of the Lower London Tertiaries $1\frac{1}{2}$ miles wide.

An alternative hypothesis is that the Bostall Common drift was once continuous with Shooters Hill gravel and at about the same level, and that it has been separated from Shooters Hill by the cutting back of the East Wickham stream, whilst denudation has lowered Bostall Common vertically from about 404 feet O.D. (the height of Shooters Hill less the gravel cap) to 234 feet O.D., by reducing the London Clay from 180 feet to 10 feet; possibly because its original capping of gravel was not so thick, and hence unable to act so protectively.[2]

The suggested hypothesis seems more workable (i.e. a trail from Shooters Hill down the slope of London Clay), and this feature

[1] "A Sketch of the History of the Rivers and Denudation of West Kent, etc.": Proc. W. Kent Nat. Hist. Soc., 1886, p. 19. This appears to be the first and only reference.

[2] There is a remarkable agreement between these figures.

may be seen at the present day at Swanscombe, in the tramway cuttings of the Associated Portland Cement Company, where foundered London Clay and its capping of gravel (different from that on Shooters Hill) trail down from Swanscombe Hill (300 feet O.D.) to about the 100 feet contour-line; the chief difference between the case of Bostall Common and that of Swanscombe being that at the latter locality the source of supply has not been cut off by a later stream, and that at the former the London Clay appears to be in situ and the drift only to have trailed.

III.—The Great Oolite Section at Groves' Quarry, Milton-under-Wychwood, Oxfordshire.

By L. Richardson, F.R.S.E., F.G.S.

On the occasion of a recent visit to the quarry in the Great Oolite at Milton-under-Wychwood, which has become known amongst geologists as "Groves' Quarry, Milton", Mr. E. T. Paris, F.C.S., and I were disappointed to find that no quarrying operations were in progress and that apparently they had ceased for good.

Messrs. Groves Brothers worked the quarry from 1846 onwards for about fifty years; but then it was acquired by a firm who afterwards traded as "The Taynton and Guiting Quarries, Limited". The Great Oolite limestone that was worked here obtained considerable repute in building circles and was of two kinds. One was derived from the whitish beds that weather into great block-like masses; and the other, from the yellower beds at the base. In the trade, both kinds were known as 'Taynton Stone'; but the first was described as 'No. 1', and said to be "a fine-grained, cream-coloured oolite"; while the second was denominated 'No. 2' and was stated to be a "similar stone, but a shade warmer".

As the faces of the workings are in danger of becoming partially hidden, and the lower beds certainly will become more and more obscured as additional talus accumulates, and as the last working to be abandoned affords the most continuous view of the component beds of the Great Oolite that there is for many miles round, it appeared desirable to record and publish a detailed account. In obtaining these details I have had the valued assistance of Mr. E. T. Paris, who has named the echinoids mentioned in the section below.

The precise position of the quarry, for which it will be probably best to retain the name of "Groves' Quarry", is two miles south-west of Shipton-under-Wychwood Church. There is a station at Shipton on the Great Western Railway line between Kingham and Oxford.

Although, following precedent, I have therefore called the quarry "Groves' Quarry", there are actually four workings at the four corners of a somewhat quadrate area, the central portion of which is occupied with vast spoil-heaps.

The south-western working was the last to be abandoned, and it was in this that the details noted below were mostly obtained.

GREAT-OOLITE SEQUENCE AT GROVES' QUARRY, MILTON, OXFORDSHIRE.

Stage	Bed	Description	Thickness in *ft.*	*in.*
UPPER STAGE.	1	Limestone and some marl, white, rubbly. This rubble (and that of the bed below when it comes near the surface) assumes a yellow colour, and one or the other or both (i.e. 1 and 2) constitute the cap to the section: about	3	0
	2	Limestone, white and pale-brown, finely oolitic; *Anabacia complanata* (Defr.), not uncommon; *Montlivaltia caryophyllata*, Lamx., *Montlivaltia* sp., *Thamnastræa lyelli*, E. & H., *Clypeus mülleri*, Wright, *Echinobrissus woodwardi*, Wright, *Volsella imbricata* (Sow.), and *Trigonia costata*, Sow.	3	0
	3	Marl, pale-brown, rather sandy, with brown and black pieces of lignite and occasional limestone pebbles	0	3
	4[1]	*a.* Marl, greyish-white (clayey and darker at the top), indurated in places; *Lucina bellona*, d'Orb., and *Unicardium varicosum* (Sow.)	2	0
		b. Limestone, white, rubbly, non-oolitic and impersistent: in places yellow-stained. When weathered forms a conspicuous yellow wavy band at the base of Bed 4*a*; *Strophodus magnus*, Agassiz, *Thamnastræa lyelli*, E. & H., ? *Isastræa limitata* (Lamx.),[2] *Trochotoma*, *Natica*, *Terebratula maxillata* auctt., *Camptonectes rigidus* (Sow.), *Grammatodon hirsonensis* (d'Arch.), *Ostrea sowerbyi*, M. & L., *Lima cardiiformis* (Sow.), *Volsella imbricata* (Sow.): 4 to 8 inches	0	6
	5	Marl of a greenish tinge weathering white; apparently unfossiliferous. The white colour of this bed, the yellow band (4*b*), and the top darker marls (4*a*) are very conspicuous in a weathered face: about	1	0
	6	TEREBRATULA-BEDS. — *a.* Limestone, white, sparsely-oolitic, crowded with *Terebratula maxillata* auctt., in places; *Clypeus mülleri*, Wright, *Hemicidaris bravenderi*, Wright (and large detached radioles probably belonging to this species), *Acrosalenia spinosa*, Agassiz, *Echinobrissus woodwardi*, Wright, *Eryma elegans*, Oppel, *Natica*, *Nerinæa*, *Rhynchonella* sp., *Serpula tricarinata*, Sow., *Camptonectes lens* (Sow.), *C. annulatus* (Sow.), *Ceromya concentrica* (Sow.), *C. Symondsi*, M. & L., *C. undulata*, M. & L., *Gervillia* cf. *waltoni*, Lycett, *Grammatodon hirsonensis* (d'Arch.), *Lucina bellona*, d'Orb., *Ostrea costata*, Sow., *Lima cardiiformis* (Sow.), *Protocardia subtrigona* (M. & L.), *Thracia curtansata*, M. & L., and *Volsella imbricata* (Sow.)	1	4
		b. Marl, greenish, with a yellow layer at the base. In places the bed above is joined on to the bed below, and when such is the case the top portion of that bed (6*c*) becomes very fossiliferous, containing many of the fossils of the bed above (6*a*); otherwise it is rather barren: 1 to 3 inches	0	2
		c. FIRST BLOCK BED.—Limestone, white, sparsely but coarsely-oolitic, massive, weathering into blocks; *Clypeus mülleri*, Wright (common), *Rhynchonella* sp. (same form as in 6*a*) .	1	6
	7	Marl, greenish-grey in the upper two-thirds, becoming browner in the lower third, with a general tendency to weather white; apparently rather barren of fossils	2	6

[1] From beds 4, 5, or 6 come some peculiar little objects that somewhat resemble crinoid-ossicles. Mr. W. D. Lang informs me, however, that they are concretions, "and similar ones are common in the chalk. Stripes on the sides are said to be slickenside structure, and the whole comparable with cone in cone structure."

[2] In this paper, when a query precedes the generic name, it indicates doubt about the genus having been accurately diagnosed.

	Bed	Description	Thickness in ft.	in.
Upper Stage.	8	*a.* Limestone, white, sparsely-oolitic, comparatively barren, and forming a cap to the limestone below (8*c*); *Nerinæa* sp., *Terebratula maxillata* auctt.: about	0	9
		b. Marl, greenish, often wanting: 0 to 4 inches	0	2
		c. Second Block Bed.—Limestone, massive, weathering into blocks, whitish, crystalline-hearted, not usually very fossiliferous; *Gervillia* cf. *waltoni*, Lycett, *Terebratula* sp.	2	0
	9	Marl, brown, clayey, with a greenish-grey zone at the centre and rubbly limestone in the lower portion; radioles of *Hemicidaris bravenderi*, Wright (common), *Ostrea sowerbyi*, M. & L., and *Serpula*: about	1	0
	10	Third Block Bed.—Limestone, not so prominent, dirty greenish-grey and brown, with white shell-fragments	1	0
	11	*a.* Marl, brown, with comminuted shells passing down into brown and grey-blotched, sandy, clayey marl, with occasional thin limestone-layers towards the base	1	0
		b. Clay-band, dark, the black colour being due to plant-remains	0	1
		c. Marl, greenish-grey, sandy, with plant-remains common. (In the south-eastern working this is the clay that appears dark.) Passes down into	0	7
	12	*a.* Limestone, greenish-grey, sandy, with an even upper surface; vertical plant-remains, the cavities where they have been weathering so as to resemble borings	0	8
		b. Fourth Block Bed.—Limestone, hard, massive, greenish-grey, weathering white and into large blocks, but internally extremely hard and somewhat resembling Carboniferous Limestone	2	0
	13	Clay, pale greenish-grey, sandy, marly	1	6
	14	Limestone, yellowish-brown and greenish, sandy, with well-spaced yellow oolite-granules. Sometimes a regular bed, but difficult to measure, practically disappearing in the south-eastern working	1	10
	15	*a.* Marl, brownish-green, often indurated to form an impure rubbly oolitic limestone, with conspicuous white oolite-granules, passing down into	1	6
		b. A conspicuous blue shaly clay[1]; *Placunopsis socialis*, M. & L., *Ostrea sowerbyi*, M. & L., *Rhynchonella* sp.: 4 to 10 inches	0	7
		c. Clay, brownish-green, marly, with occasional irregular seams of brown oolitic marl or limestone, with the same species of fossils as in 15*b*; and this into	0	8
		d. Upper Ostrea-Bed.—Marl, brown, clayey, indurated, oolitic; crowded with *Ostrea sowerbyi*, M. & L.	1	3
		The last layer (15*d*) *is intimately associated with the top portion of the bed below, which is:—*		
	16	*a.* Limestone, rubbly, oolitic, passing down into more compact, flaggy, coarsely-oolitic limestone, the weathered surfaces of the slabs of which exhibit innumerable small Gastropods, etc.; *Pygurus* sp.	2	8
		b. Thin courses of oolitic limestone and shaly marl, softer than the overlying limestone, with a hard band of very oolitic limestone at the base. This bottom band has large white oolite-granules, and is very shelly; *Isocrinus*-ossicles, echinoid-radioles, *Pseudomonotis echinata* (Sow.)	2	8
	17	*a.* Pale-yellow oolitic marl and rubble: 1 ft. 6 in. to	2	0
		b. Lower Ostrea-Bed.—Deposit of pale-yellow and yellowish marl, enclosing an extraordinary number of oysters and *Rhynchonellæ*. Most of the oysters have *Serpulæ*, polyzoans, and occasional specimens of *Webbina* on them, and are frequently pierced by the boring sponge *Talpina*, thus showing that the deposit in which they occur was of slow formation	2	8

[1] Absent as such from the south-eastern working, where bed 15*c* is thicker, tolerably conspicuous, and more of a limestone.

				Thickness in ft.	in.
LOWER STAGE.	18	*a.*	Limestone, well-oolitic, with coarser oolite-granules and shell-debris; often obliquely stratified. Splits up at the top, and greenish shaly marl is intercalated; *Ostrea sowerbyi*, M. & L.	2	6
		b.	Green and brown shale in alternating layers; lignite . .	0	6
	19	*a.*	Limestone, in three beds, oolitic and shelly in places; *Ostrea*	2	0
		b.	Rubble and marl with *Ostrea* (common); radioles: 1 to 4 in.	0	2
		c.	Limestone, massive, shelly, oolitic. Top somewhat waterworn and in uppermost 2 inches *Chlamys vagans* (Sow.) is not uncommon: seen	3	0
				50	0

South-Western Working.—This working, as already mentioned, was where the stone was last worked, and where the succession of beds from sixteen upwards was noted. The blocks that are lying about, and are so full of specimens of *Terebratulæ*, will be readily-recognized as having come from bed 6.

It will be unnecessary to say anything more about this working, as the record given above is so full.

South-Eastern Working.—In the eastern face of this working, which is the more weathered of the two, and therefore that in which the hard bands stand out in greatest relief, the principal beds that can be readily found are the disturbed top-limestones (beds 1 and 2); the rather greenish[1] marl (4*a*) with a yellow band (4*b*) at the base; the white marl (5); and then the four great block beds (6*c*, 8*c*, 10, 12*b*), of which the upper two are the most massive. The third and fourth block-beds down, when traced along the southern face of the working, become relatively inconspicuous. In the eastern face, *below* the fourth block-bed, come marls (13 and 15*a*) with a median, rather impersistent limestone (14), and then rubbly limestone (15*c*) at the very base. This rubbly limestone, when followed along the southern face, is seen immediately above the Upper *Ostrea*-Bed, which—with the Lower *Ostrea*-Bed—will form a quick means of locating the minor divisions that have been made in the lower portion of the section. It should be particularly noticed that the blue marl (15*b*) is absent as such from this working.

It is in this working that the Lower *Ostrea*-Bed is best developed and most conveniently investigated.

North-Eastern Working.—In this working—now long abandoned—the highest beds seen are those in the eastern face. The two limestones are the two top block-beds, and the second one is the top-limestone of the western face. Here, the third block-bed is poorly-developed; but the fourth is more conspicuous and has underneath it greenish marl—bed 13. The Upper *Ostrea*-Bed can be located above bed 16*a*, which is the limestone protruding at the bottom of the working.

Western Working.—This working runs below and parallel to the road. The top conspicuous limestone is the lowest block-bed (12*b*), and the green marl immediately below it is as conspicuous as ever. The Upper *Ostrea*-Bed is the next easily-found horizon. Below it is the limestone (16*a*) and the softer marls, which form the lower portion

[1] Looks greenish, but upon closer inspection is better described as 'greyish-white'.

(*b*) of bed 16; but both divisions (that is, *a* and *b*) are much thinner here. Below, again, is the greenish marl that occurs on top of the Lower *Ostrea*-Bed; while at the base of all is seen the top portion of the yellower freestone-beds, which are seen to a greater depth in a small opening to the north, nearer the cottages.

Previous Literature.—Professor E. Hull was the first to publish any remarks upon the Milton section. He wrote—[1]

"On Milton field, in a large quarry, a section similar to that at Windrush is exhibited. There we find about 17 feet of interstratified marls, shales, and thin-bedded limestones, highly fossiliferous, resting on thick-bedded oolite more than 12 feet thick, and yielding large blocks, the one belonging to the upper zone, the other to the lower."

The "thick-bedded oolite" is numbered 18 and 19 in my section.

The late R. F. Tomes visited Milton with a view to seeing if there were any corals there.[2] He found one bed (number 4 of his record) sufficiently rich in them to cause him to name it the 'Coral-Bed'; but apparently he obtained nothing worth keeping or identifiable therefrom, because all the corals he lists came from a bed lower down —his bed 6. Mr. Paris and I found corals in beds 2, 4*b*, and 6 of the record given above. Tomes also gives a record of the beds exposed at the time of this visit to show the positions of the coralliferous limestones; but whilst it is obvious that his beds 17 and 19, or at least the portions of them that contain oysters in abundance, correspond to my beds 15 and 17 respectively, it is not so easy to say more than that his bed 6, that is, "stone in large blocks," appears to be my bed 6*c*.

Mr. H. B. Woodward, the next author to notice this section, also appears to have encountered some difficulty in making out Tomes's section, for he came to the conclusion that the topmost five beds of Tomes's record "were not clearly exhibited at the time he visited the quarry". He therefore repeated Tomes's observations so far as those beds were concerned. After that he found it necessary to make his own section, which differs materially from Tomes's.

When Mr. Paris and I visited Milton there were no quarrymen about so we were unable to check our identification of the 'small land-stones' with bed 6*a* of the present record; of the 'Blue Rag' with bed 12*b*; and of the 'Bastard White Rags' with bed 14. But I think the identifications are correct, and this being so there is a noticeable correspondence between my record and Mr. Woodward's down to bed 15*d*, which is his "brown clay with *Ostrea sowerbyi* and *Rhynchonella concinna* (abundant)". But then there is a difference. Bed 15*d* is my Upper *Ostrea*-Bed, and it occurs at 7 ft. 4 in. above the Lower *Ostrea*-Bed. Above the Upper *Ostrea*-Bed is a conspicuous blue shaly clay (15*b*). Mr. Woodward notes above his "brown clay with *Ostrea sowerbyi*, etc.", "blue clay." So I think that Mr. Woodward's Oyster-Bed is really the Upper *Ostrea*-Bed, and that in going from one working to the other to complete the downward succession he may have overlooked the fact—as could easily be done—

[1] Mem. Geol. Surv.: "The Geology of the Country around Cheltenham," 1857, p. 58.

[2] Quart. Journ. Geol. Soc., vol. xli, p. 171, 1885.

that there were *two* such beds, and therefore identified the Upper *Ostrea*-Bed of one working with the Lower of the other.

As regards the Freestone-Beds, there is general agreement between the present record and that given by Mr. Woodward.[1]

In 1906 the Cotteswold Naturalists' Field Club saw Groves' Quarry, and it was remarked that the beds were less massive than those of the Great Oolite that were quarried in the neighbourhood of Bath.[2]

It is not purposed attempting any detailed correlations of the beds in this section with those elsewhere. The time is not ripe; but it may be as well to draw particular attention to the following points:—

(1) The somewhat abundant occurrence of specimens of *Anabacia complanata* (Defrance) in bed 2, and the presence of the echinoids, *Echinobrissus woodwardi*, Wr., and *Clypeus mülleri*, Wr.

(2) The very fossiliferous nature of bed 6, all the fossils being noteworthy for correlation-purposes.

(3) The relative barrenness of the marl-beds associated with the fossiliferous top-limestones.

(4) The distinctive lithic structure of bed 14 and its richness in specimens of *Cypricardia* spp. and *Volsella imbricata* (Sow.), and to a less extent in certain other Lamellibranchs.

(5) The not infrequent occurrence of *Placunopsis socialis*, M. & L., in bed 15*b*.

(6) The occurrence of *two* conspicuous *Ostrea*-Beds (15*d* and 17), 7 ft. 4 in. apart. The oysters in the lower bed are usually encrusted with *Serpula tricarinata*, Sow., *Berenicea* spp., occasionally with *Webbina*, and are frequently pierced by the boring sponge *Talpina*.

IV.—The Post-Pleistocene Flora and Fauna of Central England.

By A. R. Horwood,

Leicester Museum.

The central position of Leicestershire gives it not only a peculiar relationship in regard to river-drainage, streams radiating from its plateau-frontier on the one hand to the north, flowing into the Humber, and on the other to the south into the Bristol Channel, separated alone by a now comparatively insignificant divide in the neighbourhood of Lutterworth. Also the very fact that this divide is given, by the otherwise lowland character of the tract to the north and south, a barrier-like aspect, renders it highly probable that the flora and fauna in this basin-like area is more or less homogeneous. That it has been uniform in character, no doubt from pre-Glacial times, when doubtless the existing drainage systems (though probably still more ancient fundamentally) received their most recent stamp, having been little modified (except in depth or width) during Glacial or later times. For this purpose we must needs summarize all that is known as to the occurrence of plants or land and freshwater Mollusca in post-Pleistocene alluvial deposits.

[1] *The Jurassic Rocks of Britain—The Lower Oolitic Rocks of England (Yorkshire excepted)*, vol. iv (1894), p. 307.

[2] Proc. Cotteswold Nat. F.C., vol. xvi, pt. i, p. 32, 1907; see also *Geology in the Field* (Jubilee vol. of the Geol. Assoc.), pt. 2, p. 356, January, 1910.

Soar Valley.

In the county of Leicester itself no adequate account of any post-Pleistocene remains other than mammalia[1] has been published. The first notice is the result of a natural history competition which was carried on for some years before the present Museum had assumed any important position. Mr. F. T. Mott[2] reported the discovery of shells of the genera *Limnæa*, *Succinea*, etc., in gravel at Belgrave,[3] stained with iron-oxide. This gravel is doubtless part of the alluvial sand and gravel which covers the lower part of the Soar Valley. This locality is north of the town. Somewhat to the south another locality, Aylestone (excavations for gasworks),[4] has afforded more abundant evidence of a flora and fauna similar to the existing one. Here in the Soar Valley the following section was exposed:—

	ft.	in.
1. Materials of a cart road	0	6
2. Rough gravel (perhaps foundation of a road) .	1	0
3. Fine grey clay	5	0
4. Black peat	1	6
5. Soft white calcareous marl	2	0
6. Red marl in situ.		
	10	0

The lowest bed (5) was said to consist largely of *Chara*, and amongst the calcareous remains of the plant and seeds were numbers of fresh-water shells, *Limnæa*, *Planorbis*, *Pisidium*, *Cypris*, and other animal remains.

The following is a list of the specimens found which passed into the hands of the late Mr. J. Plant, who gave them to the Museum:—

Plantæ.
- *Chara vulgaris.*
- cf. *Potamogeton zosteræfolius.*

Annelida.
- Tubes.

Crustacea.
- cf. *Candona candida.*

Gasteropoda.
- *Hyalinia cellaria.*
- *H. pura.*
- *Helix pulchella.*
- *H. hispida.*
- *Cochlicopa lubrica.*
- *Pupa muscorum.*
- *Succinea putris.*
- *Ancylus fluviatilis.*
- *Limnæa peregra.*
- *L. peregra*, var. *ovata.*
- *L. auricularia.*
- *L. truncatula.*
- *Bythinia leachii.*
- *Planorbis nautileus.*
- *P. fontanus.*
- *P. spirorbis.*
- *P. parvus.*
- *P. umbilicatus.*
- *Valvata piscinalis.*

Lamellibranchiata.
- *Sphærium corneum.*
- *Pisidium amnicum.*

A single worn fragment of *Ostrea edulis* was amongst these otherwise lacustrine forms. The section was first noticed by the late Mr. W. J. Harrison, F.G.S., a former Curator. The deposits are

[1] A list of these up to 1889 was given in *The Vertebrate Animals of Leicestershire and Rutland.* It was summarized recently in the "Victoria County History" by Mr. R. Lydekker. Many additions must, however, be made to both.

[2] Report Leic. Lit. and Phil. Soc., 1875, p. 42.

[3] Mr. J. Plant found Rhinoceros teeth with *Succinea*, *Limnæa*, etc., in the Abbey Park Road, a little north of the south end.

[4] Ibid., 1878, pp. 26–8.

distinctly alluvial. The site was about 100 feet at most from the River Soar. At a depth of 11 feet and below Boulder-clay resting on Red Marl an antler of *Rangifer tarandus* was found close to the same spot. In the river gravels and alluvium at various points in the Soar Valley the following mammalia have been found, at the Abbey Meadow, Belgrave, Humberstone, Thurmaston, Aylestone, Barrow-on-Soar, Loughborough, Kegworth, Syston, Thurnby, Melton Mowbray, and elsewhere:—

Bison bonasus, var. *priscus*.
Bos taurus, var. *primigenius*.
Cervus elaphus.
Elephas antiquus.
Elephas primigenius.
Rangifer tarandus.
Rhinoceros leptorhinus.

Whilst the foregoing may be Glacial, the following are of more recent date:—

Bos taurus, var. *longifrons*.
Capra or *Ovis* sp.
Capreolus caprea.
Cervus dama.
Cervus elaphus.
Equus caballus.
Sus scrofa.

As to molluscan remains in Glacial beds themselves Messrs. G. W. Lamplugh and C. Fox-Strangways are said to have found *Tellina balthica* at Beasley's Sandpit, Aylestone, in the Quartzose Sand, but M. Browne[1] threw discredit on the discovery. We must say that there is no reason to doubt their occurrence, and we have found shell fragments there and elsewhere, though too fragmentary—as most Glacial contemporaneous fossils are—to determine.

Lower Trent Valley.

Passing to the north-west corner of Leicestershire and the Trent Valley, we find evidence of a similar flora and fauna in the Burton-on-Trent district. Here at Stapenhill alluvial deposits occur 17 feet above the Trent, and Mr. W. Molyneux, F.G.S.,[2] gave the following section:—

	ft.	in.
1. Red clay	4	0
2. Stiff yellow clay	0	6
3. Black and yellow clay, gradually passing into a strong unctuous clay	1	3
4. Peat containing shells and thickly charged with small crystals of sulphate of lime	1–3	0
5. Strong yellowish-brown clay, the upper part thickly charged with shells	4	0
6. Band of coarse gravel	0	3
7. Hard consolidated, stratified sand, with few pebbles	2	0
8. Loose current-bedded white and yellow sand, intersected by thin bands of peat, clay, and pebbles, and frequently containing lumps of coal and black shale	10	0
9. Coarse white and yellow clayey gravel containing bones of animals		
	23–5	0

[1] Trans. Leic. Lit. and Phil. Soc., 1901, p. 30.
[2] *Burton-on-Trent, its History, its Waters, and its Breweries*, 1869, p. 182.

R. Garner, author of the *Natural History of Staffordshire*, identified in bed 5 the following shells:—

Helix pulchella.	*Vertigo* sp.
H. rotundata.	*Succinea oblonga.*
H. fulva.	*Planorbis* sp.
Buliminus obscurus.	*Limnæa peregra.*
B. sp.	*L. truncatula.*
Vertigo substriata.	

In addition to these a diatom, *Fragillaria*, was detected, and the wing of an insect, the elytron of a beetle, etc., but not in the peat with the shells. In a field south of this section another was seen—

1. Brown clay	6 inches to 2 feet.
2. Dark earthy sand	1 foot.
3. Coarse ochreous gravel	1 to 2 feet.
4. Current-bedded sand with veins of clay	4 to 6 feet.
	6 ft. 6 in. to 11 feet.

In bed 4 roots of aquatic plants, probably *Iris*, were found, passing up through the gravel above, becoming ochreous in colour. The claw of a cray-fish, *Astacus fluviatilis*, was found in the gravel. At Stretton, on the opposite or north side of the river, the section is—

	ft.	in.
1. Strong red clay and gravel	10	0
2. Yellow gravel and sandy clay	5	0
3. Yellow sand and gravel	1	0
4. Blue clay and gravel passing into strong clay, the upper surface containing a band of from 2 to 3 inches of black peaty matter	2	0
5. Coarse yellow gravel	0	9
6. White and yellow sand and clayey gravel, with subangular flints	3	0
7. Strong red marly clay and gravel	2	0
8. Tenacious dark-blue clay	2	3
9. Deep yellow ochreous sand	0	3
10. Strong white clayey gravel, bottom not seen	4	0
11. Blue and brown clays	–	–
	30	3

In No. 4 fragments of wood and plants have been found and aquatic plants in No. 8. In No. 4 very large blue and yellow flints derived from the Drift occur.

In the river-gravels at Andersley, at 3–5 feet deep, roots and branches of trees occur, and at a lower level also, in addition, hazel-nuts, aquatic shells, and bones of mammalia. Professor Boyd Dawkins identified the latter as bones, jaws, and teeth of *Sus scrofa*, *Bos longifrons*, and domestic varieties, *Equus*, and bones of wolf or dog, while similar remains have been found at Burton itself, near Whitehead's Brewery, Mosley Street old river-course, sewer excavations at Anderstaff Lane, and at Stretton. At the Hay, below 3 ft. 6 in. of sand and gravel, in stiff blue and yellow clay, roots and branches of trees and other plants were found, and below the latter peat (1 ft. 9 in.). At Mosley Street, below 5 feet of clay, 8 feet of peat was met with.

Below this last horizon, in black consolidated gravel (8 feet thick), Edwin Brown found—

CRUSTACEA.
Daphnia.

GASTEROPODA.
Vertigo.
Cochlicopa lubrica.
Succinea putris.
Planorbis albus.
P. spirorbis.
Planorbis contortus.
Physa fontinalis.
Limnæa peregra.
L. palustris.
L. stagnalis.
Bythinia tentaculata.

LAMELLIBRANCHIATA.
Sphærium corneum.

Most of these too were found at Hay, Mosley Street, and in excavations for sewage tanks at Stretton. Compared with those found in the peats and clays at Stapenhill on the other side there is a difference in species. At Barton Station, south of Burton, roots of plants and branches of trees were met with, and containing an admixture occasionally of peat, 2 feet in thickness, below 6 ft. 2 in. of clay, sand, and gravel.[1] The latter were impregnated with carbonate of iron and manganese, containing much vegetable matter. In forming No. 3 tank at Stretton the following section was uncovered:—

1. Yellow clay	1 foot.
2. Blue clay, containing plants . .	6 inches.
3. Peat	3 feet.
4. Shell marl, with bones, jaw, teeth (*Bos longifrons*)	1 to 8 feet.
5. Gravel with flints, bottom not seen .	3 feet.
	8 ft. 6 in. to 15 ft. 6 in.

The deposits were very variable, the shell marl full of shells, irregular, sometimes lying on gravel, sometimes on peat, or dark clay with aquatic shells. Plant roots penetrate from the peat through the shell marl into the gravel. In the blue clay matted masses of aquatic plants occur coated with phosphate of iron. Dr. H. T. Brown, F.R.S.,[2] gives the following section at the Sewage Works near Stretton (140 O.D.):—

	ft.	in.
1. Soil, subsoil, and sand	3	0
2. Sandy clay	0	5
3. Red sand	1	4
4. Thin bed of peat	0	2
5. Sand stained with peat	1	0
6. Dark peaty clay, more peaty below . . .	2	4
7. Peat, with sedges and hazel-nuts . . .	1	11
8. Irregular bed of sand, coloured by peat, with a thin, irregular bed of gravel (1 to 2 inches), in other places a highly calcareous shell marl .	1	0
9. Very thin beds of interstratified clay and sand .	3	0
10. Gravel	5	0
Marl below.		
	19	2

[1] About 30 feet below the surface in the gravels a deer's horn was found.
[2] Vide *The Geology of the Country between Derby, Burton-on-Trent, and Loughborough*, 1905, p. 64.

About 30 yards west the gravel is 3 feet nearer the surface. The fauna was as follows:—

CRUSTACEA.

Cypris.

GASTEROPODA.

Segmentina nitida.[1]
Planorbis parvus.
P. contortus.
Physa fontinalis.
Amphipeplea glutinosa.[2]
Limnæa auricularia.
L. stagnalis.
L. peregra.
Velletia lacustris.
Bythinia tentaculata.
Valvata piscinalis.

In a trench cut at Hay, peat, 6 to 9 inches thick, was found with hazel-nuts at the bottom, at a depth of 6 ft. 7 in.; and at Annesley Meadow at a depth of 2 ft. 7 in. in stiff clay, with a layer of vegetable mould 7 inches above; and in another section south-east of a large well belonging to Messrs. Bass, 45 yards from the River Trent, there was a layer of vegetable mould 6 inches thick succeeded by clay, with some peaty matter (4 feet) changing into gravel coloured by peat, the peaty clay thickening towards the river.

DERWENT VALLEY.

The lacustrine clay of Sinfin Moor is shown in the following section:—

	ft.	in.
1. Black peat	1	2
2. Disintegrated shells	0	3
3. Stiff yellow clay	2	0
4. Shells	2	0
5. Quicksand	3	0
	8	5

In the Erewash Valley the following plants, Crustacea, shells, etc., have been found and identified by Mr. Clement Reid, to whom the writer is indebted for assistance in the readiness with which he has been supplied with literature on this subject:—

PLANTÆ.

Lycopod spores.
Scirpus lacustris.

CRUSTACEA.

Daphnia.

INSECTA.

Chrysalis cases.

GASTEROPODA.

Limnæa peregra.
Bythinia tentaculata.
Valvata piscinalis.
Viviparus sp.

LAMELLIBRANCHIATA.

Sphærium corneum.

At Allenton, near Derby, also in the Derwent Valley, Mr. Arnold Bemrose[3] found the following plants, with *Hippopotamus*, *Elephas*, *Rhinoceros*:—

Ranunculus aquatilis.
R. sceleratus.
R. flammula.
R. repens.
R. ? bulbosus.
R. sardous.
Viola palustris.
Montia fontana.
Rubus idæus.
Potentilla sp.

[1] Found in E. and W. Norfolk, Cambridge, Worcester, Montgomery, N. Lincs, S. and W. Lancs.

[2] The nearest counties where this is now found are: Kent, Berks, Bucks, E. Suffolk, E. Norfolk, Huntingdon, N.E. and S.E. York, N. Lincoln, Huntingdon.

[3] Quart. Journ. Geol. Soc., vol. lii, pp. 497–500, 1896.

Hydrocotyle vulgaris.
Valeriana officinalis.
Eupatorium cannabinum.
Leontodon autumnalis.
Taraxacum officinale.
Ajuga reptans.
Atriplex.
Eleocharis palustris.
Scirpus pauciflorus.
Carex.
Isoetes lacustris.

According to Mr. Reid this flora is Interglacial, and it is undoubtedly Pleistocene, judging from the associated mammals, but we include it for comparison with the later floras.

Higher Trent Valley.

In the higher reaches of the River Trent, in alluvium of the tributary Cocker Beck, the following mammalia were recognized by E. T. Newton[1]:—

Human femur.
Horse.
Ox (? *Bos longifrons*).
Sheep or goat.
Pig.
Dog or wolf.

Mr. Clement Reid recognized in the silt the following plants:—

Ranunculus aquatilis.
R. flammula.
R. acris.
Fumaria officinalis.
Arenaria trinervia.
Spergula arvensis.
Montia fontana.
Prunus spinosa.
P. padus.
Rubus.
Potentilla tormentilla.
Apium graveolens.
A. nodiflorum.
Cornus sanguinea.
Sambucus nigra.
Carduus palustris.
Solanum dulcamara.
Mentha aquatica.
Galeopsis tetrahit.
Stachys sylvatica.
Chenopodium rubrum.
Rumex conglomeratus.
Urtica dioica.
Corylus avellana.
Scirpus lacustris.
Carex spp.

The following shells were also found:—

Pisidium pusillum.
Sphærium sp.
Acanthinula lamellata.
Carychium minimum.
Clausilia cf. *rugosa.*
C. sp.
Cochlicopa lubrica.
Helix hortensis.
H. lapicida.
H. nemoralis.
H. pulchella.
Limnæa cf. *peregra.*
L. truncatula.
Physa hypnorum.
Planorbis nitidus.
P. spirorbis.
Pupa anglica.
P. cylindracea.
Pyramidula rotundata.
Succinea elegans.
S. putris.
Vertigo alpestris.
V. antivertigo.
V. pusilla.
Vitrea cellaria.

Peat and vegetable matter were noticed in sewer cuttings at old Basford in the Leen Valley; and in peat at Old Radford, *Quercus robur* and *Pinus sylvestris* were observed by Mr. Shipman. At Clifton two teeth of *Elephas primigenius* were discovered 6 feet deep in brick-earth, and at Sneinton, close to Nottingham, a band of peat (12 to 18 inches) was found by Mr. Shipman, containing hazel-nuts and *Bos longifrons.*

[1] *The Geology of the Country between Newark and Nottingham* (Mem. Geol. Surv.), 1908, p. 86.

South of the Trent the Thirlbeck River alluvium has yielded—

Bythinia leachii.
B. tentaculata.
Hygromia hispida.
Limnæa peregra.
Planorbis complanatus.
Planorbis marginatus.
Sphærium corneum.
S. rivicola.
Unio sp.

The Car Dyke alluvium also afforded—

Bythinia tentaculata.
Helix nemoralis.
Hygromia hispida.
Limnæa peregra.
Planorbis marginatus.
P. spirorbis.
Sphærium corneum.

At Edwalton the following were found:—

Bythinia tentaculata.
Clausilia cf. *rugosa.*
Limnæa palustris.
L. peregra.
Planorbis marginatus.
Pyramidula rotundata.
Vitrea cellaria.

Vale of Belvoir.

The alluvium of the River Devon contains the following shells:—

Bythinia tentaculata.
Hygromia hispida.
Limnæa palustris.
L. peregra.
Neritina sp.
Valvata piscinalis.
Unio cf. *pictorum.*

In the late glacial deposits at Kirby Park the tooth of a mammoth was found, which is now in the Woodwardian Museum, and was figured by Leith Adams ("The Brit. Foss. Elephants": Pal. Soc., 1879, pl. xiii).

At Hose[1] in brown loam freshwater shells are found in the Smite Valley.

In Barnes' brickyard north of Melton in the Eye Valley, at a depth of 9 feet in sand, boles and roots of trees, with bark and hazel-nuts, occur. Mammalian bones occur in gravel below this, including a human cranium, and bones and antlers of the red deer.

Valley of River Welland.

The deposits differentiated in the area covered by old Sheet 64 were grouped by Professor J. W. Judd[2] as follows:—

Post-Glacial.
1. Marine alluvium, warp of Fens.
2. Alluvium of present rivers.
3. Alluvium of old fen lakes.
4. Peat interstratified with marine silt.
5. Marine gravels of Fenland.
6. Estuarine gravels.
7. Low-level valley gravels.
8. High-level valley gravels.
9. Cave deposits.

He defined the glacial beds as—

1. Glacial or Boulder-clay.
2. Gravels.
3. Sands.

[1] *The Geology of the Melton Mowbray District and South-East Nottinghamshire* (Mem. Geol. Surv.), 1909, p. 89.

[2] *Geology of Rutland*, 1875, p. 56.

But he admitted this was only a provisional arrangement, and much subsequent subdivision has been made.[1]

He classed as pre-Glacial the following:—

1. Pebbly gravels and sands.
2. Brick-earths.
3. River gravels.
4. Lacustrine deposits.

In referring to the deposits mentioned below as pre-Glacial at Casewick, Mr. Clement Reid indeed regards them as Neolithic, but they may be, he says, "of older date." He records *Nuphar luteum*, *Galium aparine*, *Atriplex patula*, *Rumex crispus*, in addition to those given below. But we only here need consider those deposits in which land or freshwater mollusca occur, so that these modifications do not affect the case, for it is rarely that any molluscan remains are found in the Boulder-clay itself in the Midland area,[2] whilst the few instances of marine shells in the pre-Interglacial or post-Glacial beds are mentioned only to indicate where lacustrine and marine conditions alternated.

It is in the lacustrine deposits alone that plants and shells have been found in the above area. Thus Professor Morris[3] discovered a freshwater deposit at Casewick in a hollow of the Kellaways rock covered in turn by glacial beds. The section was—

	ft.	in.
1. Gravel and sand in wavy seams	7–8	0
2. Sand and gravel, with *Belemnites*, *Gryphæa*, etc. .	3	0
3. Freshwater deposit, grey, sandy clay . . .	2	0
4. Freshwater deposit, brown, sandy clay and veins of gravel	1	6
5. Freshwater deposit, peaty clay with plants and shells	1	6
6. Freshwater deposit, dark sandy clay with plants and shells, with pebbles of chalk and flint and fragments of northern clay drift, the base being extremely irregular	3	0
	18–19	0

The plants, Crustacea, etc., were as follows:—

Plantæ.

Ceratophyllum demersum.
Equisetum.

Crustacea.

Candona ? lucens (juv.).
C. reptans.
Cypris (small species).

Gasteropoda.

Helix aculeata.
H. pulchella.
H. hispida.
Succinea putris.
Carychium minimum.
Planorbis carinatus.
P. umbilicatus.
Limnæa peregra.
Ancylus fluviatilis.
Velletia lacustris.
Bythinia tentaculata.
Valvata piscinalis.
V. cristata.

Lamellibranchiata.

Sphærium corneum.
Pisidium amnicum.
P. amnicum, var. *pulchella.*
P. pusillum.
P. pusillum, var. *obtusalis.*

[1] R. M. Deeley, Quart. Journ. Geol. Soc., vol. xlii, p. 437, 1886.

[2] At Beasley's Pit, Aylestone, Mr. G. W. Lamplugh and the late C. Fox Strangways found *Tellina balthica.*

[3] Quart. Journ. Geol. Soc., vol. ix, p. 321, fig. 2, 1853.

In addition to these contemporary species were derived fossils from the Oxford Clay—

Cerithium.
Arca.
Belemnites.
Echinus.
Other marine remains.

A comparison between the proportional number and the species represented in these pre-Glacial deposits and those found in the post-Glacial beds shows how very similar in species and general character the periods preceding and following the Glacial Period were. If we regard these pre-Glacial beds as really mid-Glacial or Interglacial the comparison is equally interesting.

Another bed 3 miles to the west in the River Gwash Valley contains land shells and bones, being possibly slightly later. In the deposits actually assigned to the Glacial epoch no contemporary molluscan remains were noticed by Professor Judd.

Passing to the post-Glacial deposits, with which we are more directly concerned, the only cave deposits are those at Tinkler's Quarry, Stamford. Professor Rolleston identified the following:—

Hyæna (teeth).
Elephas (tooth).
Cervus megaceros (tooth).
Cervidæ, various.

This cave was said to have been 15 to 20 feet square, and was doubtless a hyæna cave to which prey had been conveyed. The long bones were broken and some had been gnawed.

In the overlying valley gravels, locally in thin sandy loam, molluscan remains occur, but are not common, whereas mammalian remains are, including living and extinct types intermingled, as *Elephas*, rhinoceros, hippopotamus, hyæna, horse, red deer, and urus. No flint implements had been found at the time in these gravels. Above these a loam, like the loess, containing remains of living terrestrial shells, occurs near Peterborough. Mammalian remains occur in gravel at Helpston, including the Mammoth.

In the estuarine gravels both freshwater and marine shells occur at Peterborough, and at Overton Waterville the following: *Ostrea edulis*, *Cardium edule*, and the land and freshwater species *Planorbis carinatus*, *Limnæa glutinosa*, *Ancylus fluviatilis*, *Bythinia tentaculata*, *Pisidium amnicum*. The following mammalian remains were associated with them: *Elephas primigenius*, *Rhinoceros tichorhinus*, *Equus caballus*, *Canis lupus*, *Hyæna spelæa*, *Cervus elaphus*, *Bos primigenius*.

Limnæa (*Amphipeplea*) *glutinosa*, an extremely local species, is still found in South Lincolnshire and in Northampton, East Norfolk, Bucks, Berks, and East Kent, but is otherwise rare.

In the marine gravels of the Fenland the fauna includes mollusca and mammalia, viz.: *Littorina littorea*, *Turritella communis*, *Buccinum undatum*, *Tellina solidula*, *Ostrea edulis*, *Mytilus edulis*, *Cardium edule*, *Cyprina islandica*. This last, though now rare, is still found in the North Sea. The peat, and marine silt which is interstratified with it, contains a diversified flora and fauna. In the peat, made up largely of *Sphagnum* and other bog-mosses, stools of trees are found, e.g. oak, birch, etc. These are often found washed out and waterlogged along the Lincolnshire coast. Of mammals the following occur: *Bos primigenius*, var. *longifrons*, Irish elk, wild boar, red deer, bear, otter, beaver, wolf, fox. In the buttery clay marine shells occur, viz.: *Ostrea edulis*, *Cardium edule*, *Scrobicularia piperata*. Foraminifera have also been found, and remains of marine mammals, whale, and seal are not uncommon.

In the alluvium of the Old Fen lakes or meres of Whittlesea, Ramsey, Ugg, etc., the alluvium or silt is crowded with *Unio*, *Anodon*, *Paludina*, *Planorbis*, *Limnæa*, forming a shell marl. The alluvium of the present rivers contains also a considerable flora and fauna, and consists of black loam or silt, reformed by modern rivers, and continually being augmented year by year. In the Nene and Welland valleys these are very extensive. In the Fens the marine alluvium or warp is found near Crowland, and resembles the silt found associated with peat at a lower horizon.

Valley of River Nene.

In a fissure of the Lincolnshire Oolite at Brigstock, Mr. A. Wallis found recent land and freshwater shells, and Mr. Beeby Thompson [1] explained their occurrence as due to disturbance of Lincolnshire Oolite and redeposition with introduction of the shells at the time of the latter. He suggests their pre-Glacial age, and preservation in Interglacial clay. This would lend support to the earlier age of the shells at Casewick, also in a fissure. In a later paper Mr. Beeby Thompson [2] includes these shell deposits in the late mid-Glacial gravels, which underlie the Upper or Chalky Boulder-clay.

The shells that were found were—

Succinea putris.	*Helix nemoralis* or *arbustorum.*
Cochlicopa lubrica.	*Pupa marginata.*
Helix pulchella.	*Pisidium pusillum.*

In valley gravels *Elephas antiquus*, *E. primigenius*, *Rhinoceros tichorhinus*, *R. leptorhinus*, *Hippopotamus major*, *Equus caballus*, *Bison priscus*, *Bos primigenius* are found, tusks and teeth in the upper part of the Nene Valley, lower down near Peterborough marine shells, *Cardium* and freshwater species of *Physa*, *Limnæa*, *Planorbis*. At Elton and Northampton Mammoth occurs.

In river alluvium at Martin's brickyard Mr. H. N. Dixon [3] found—

Nuphar luteum.	*Polygonum.*
Stellaria media.	*Mercurialis perennis.*
Prunus spinosa.	*Alnus.*
P. padus.	*Corylus avellana.*
Sambucus nigra.	*Quercus robur.*

Mammalia, *Bos longifrons* and *B. primigenius*, horse, sheep, wild hog, red deer, freshwater mollusca, and human remains, often coated with vivianite, also occur.

For comparison with localities farther removed from the central tract of Leicestershire, we add a list of plants, etc., found outside the midland or central tract. At Dursley, Gloucestershire, to the south-west, a calcareous tufa in process of formation is full of leaves. Miss M. A. and Mr. Clement Reid [4] found leaves of hazel, elm, and hart's tongue in it.

[1] Geol. Mag., 1895, pp. 1–3, reprint. [2] Proc. Geol. Assoc., 1910, p. 485.
[3] *The Origin of the British Flora*, Clement Reid, F.R.S., 1899, p. 13.
[4] Ibid., p. 66.

At Wolvercote, near Oxford, to the south, in an alluvial deposit lying over Palæolithic implements and bones of Bison, the following were found :—[1]

Ranunculus aquatilis.	*Heracleum sphondylium.*
R. sceleratus.	*Potamogeton.*
R. repens.	*Eleocharis palustris.*
Potentilla tormentilla.	*Scirpus lacustris.*
Viola.	*Carex rostrata.*
Hippuris vulgaris.	

Compared with results obtained in Scotland and East Anglia, the record of life in the post-Pleistocene deposits of Central England is meagre, and shows what needs yet to be done. The survey of the localities where material has been found, in this summary, may have the desired effect of stimulating further investigation.

As regards glacial deposits, it is probable that careful examination of accumulations such as the quartzose sand with interstratified carbonaceous layers may have good results.

The occurrence of several species of living land and freshwater shells in the mid-Glacial gravels, at Brigstock and at Casewick (not certainly of this age at the last locality, but probably), lends support to the pre-Glacial origin of the prototypes of our land and freshwater mollusca. The known existence of many of the plants found with the mollusca in pre-Glacial times, e.g. *Ranunculus aquatilis*, *R. sceleratus*, *R. repens*, *Nuphar luteum*, *Stellaria media*, *Prunus spinosa*, *Heracleum sphondylium*, *Atriplex patula*, *Betula alba*, *Alnus glutinosa*, *Corylus avellana*, *Quercus robur*, *Ceratophyllum demersum*, *Pinus sylvestris*, *Alisma plantago*, *Eleocharis palustris*, *Scirpus lacustris*, *Isoetes lacustris*, etc., lends support to this notion. Moreover, the universal distribution of certain species of mollusca throughout this central region is also evidence of their greater antiquity, viz. :—

Hyalinia cellaria.	*Limnæa peregra.*
Helix pulchella.	*L. auricularia.*
H. hispida.	*L. stagnalis.*
Cochlicopa lubrica.	*Ancylus fluviatilis.*
Succinea putris.	*Bythinia tentaculata.*
Planorbis spirorbis.	*Valvata piscinalis.*
P. umbilicatus.	*Sphærium corneum.*
Physa fontinalis.	

To this may be added the homogeneity, in general, of the mammalian fauna found in association with both the plants and other animals of the post-Pleistocene deposits.

V.—The Residual Earths of British Guiana commonly termed 'Laterite'.

By Professor J. B. Harrison, C.M.G., M.A., F.G.S., F.I.C., assisted by K. D. Reid, Assistant Analyst British Guiana.

(*Concluded from the November Number*, p. 495.)

The losses of their constituents during the decompositions of the rocks.— As shown in this paper the analyses of the rocks and of their decomposition-products do not indicate the extent of the degradation which

[1] *The Origin of the British Flora*, Clement Reid, F.R.S., 1899, p. 61.

has taken place. To ascertain this it is necessary to re-calculate the analytical figures so that their proportions are comparable to those of one of the constituents which is assumed to have remained unchanged. The structures of the Surinam and the British Guiana bauxitic laterite show clearly that, contrary to what is not unfrequently assumed, alumina cannot be regarded as a static component in rocks and their decomposition-products. It is evidently under condition of lateritization capable of entering into solution, transference from place to place, and redeposition in the form of alumina hydrate where conditions are favourable. The constituent which appears to be the most stable under conditions of weathering is titanium oxide, especially that present as ilmenite. But unfortunately as a rule it is present in such low proportions in rocks and in their residuary products that, when taken as the static constituent, errors in analysis of low value are productive of variations of wide extent in the results calculated on them.

When calculations of this sort are made on the epidiorite of Issorora and on the lateritic earth with its enclosed pisolites the difficulty arises that the iron in the earth and in its enclosed pisolites has not been derived only from the portion of the rock which has given rise to the earth, but is largely an infiltration product from other lateritic earth which has been removed by denudation.

The results calculated on titanium oxide as the static constituent are as follows:—

TABLE XVIII.

	Original Epidiorite.	Earth with Pisolites.
Silica	49·06	7·51
Aluminium Oxide	18·87	10·69
Iron Protoxide	6·38	
Iron Peroxide		21·26
Magnesium Oxide	10·95	·21
Calcium Oxide	11·70	·11
Sodium Oxide	·97	·02
Potassium Oxide	·06	·09
Water	·43	3·66
Titanium Oxide	·88	·88
Manganese Oxide	·34	·01
	99·64	44·44

The excess of iron, the increased amount of water, and the gain in weight of the oxidation of the protoxide of iron in the original rock being eliminated, it is seen that of 100 parts of the constituents of the epidiorite only 26·4 remain in the laterite and that therefore a loss of 73·6 per cent. of the epidiorite has taken place. This loss falls on its constituents in the following proportion shown as losses per 100 parts of each:—

TABLE XIX.

Silica	84·7
Aluminium	43·4
Magnesium Oxide	98·1
Calcium Oxide	99·1
Sodium Oxide	97·9
Manganese	97

Similar calculations based also on the assumption that the titanium oxide is the static constituent have been made with regard to the Tumatumari, Omai Falls, and Mazaruni laterites. Their results are given in Table XX—

TABLE XX.

	Tumatumari.		Omai Falls.		Mazaruni.	
	Diabase.	Laterite.	Diabase.	Laterite.	Hornblende Schist.	Laterite.
Silica	51·19	30·43	53·25	29·90	51·70	15·84
Aluminium Oxide . . .	15·80	15·80	17·16	11·78	15·94	11·38
Iron Protoxide	14·28		12·53		14·40	
Iron Peroxide		6·40		14·30		2·55
Magnesium Oxide . . .	5·63	·13	6·10	·08	5·54	·04
Calcium Oxide	9·58	·14	7·46	·07	9·60	·003
Sodium Oxide	2·09	·08	2·50	·10	1·87	·18
Potassium Oxide . . .	·60	·12	·69	·30	·08	·16
Water	·30	6·77	·32	7·02	·30	3
Titanium Oxide	·40	·40	·32	·32	·30	·30
	99·87	60·27	100·33	63·87	99·73	33·453

Allowing for the gain in water in each of them, for the oxidation of the protoxide of iron, and for a small excess of iron peroxide due to infiltration in the Omai Falls sample, we have losses of 47·4, 44·6, and 70·5 per cent. respectively of the original rocks during their degradation to laterite. The loss per 100 parts of each constituent of them is as follows:—

TABLE XXI.

	Tumatumari.	Omai Falls.	Mazaruni.
Silica	40·5	43·6	69·3
Aluminium . . .	nil	31·3	28·6
Iron Peroxide . .	58·7	nil	83·6
Magnesium Oxide .	97·7	98·7	99·2
Calcium Oxide . .	98·5	99·1	99·9
Sodium Oxide . .	96·1	96	90·4
Potassium Oxide . .	80	47·8	nil

The range of variation in the losses of alumina and oxide of iron is wide, being for alumina from *nil* to 31·3 per cent. and for oxide of iron from *nil* to 83·6 per cent.

The most interesting points in the above results are the great loss of combined silica and the change of some of the silica set free into quartz. Thus, in the Tumatumari sample 46·01 of the combined silica present in the rock is not found in that form in the derived laterite, but 25·2 of the silica set free has been changed into quartz; in the Omai Falls sample 41·7 of the combined silica has disappeared, leaving in its place 18·2 of quartz; and in the Mazaruni sample 39·1 of the combined silica has been apparently lost from that condition, whilst only 3·2 of it remains as quartz.

The following changes are indicated as having occurred during the degradation of the granite and the hornblende-granites at Mazaruni and Mahdia:—

Table XXII.

	Mazaruni.		Mahdia.	
	Granite.	Pipe-clay.	Hornblende Granitite.	Pipe-clay.
Silica	73·81	49·61	68·20	29·04
Aluminium Oxide . .	13·93	14·47	15·83	11·30
Iron Peroxide . . .	1·41	1·49	3·43	1·21
Magnesium Oxide . .	·72	·07	2·14	·18
Calcium Oxide . . .	·88	nil	3·49	·04
Sodium Oxide . . .	2·80	·28	3·07	nil
Potassium Oxide . .	4·81	·36	2·88	·18
Water	·74	6·22	·50	3·15
Titanium Oxide . .	·62	·62	·46	·46
	99·72	73·12	100	45·56

Allowing for the added water in each and for slight apparent increases in the alumina and iron oxide of the Mazaruni specimen, there is a loss of 33 per cent. of the constituents in the case of the granite and of 54·5 per cent. in the case of the hornblende granitite. The losses in each 100 parts of the various constituents work out as follows:—

Table XXIII.

	Mazaruni.	Mahdia.
Silica	32·8	57·4
Alumina	nil	28·4
Iron Oxide	nil	64·7
Magnesium Oxide . .	90·3	91·6
Calcium Oxide . . .	100	98·8
Sodium Oxide . . .	90	100
Potassium Oxide . .	92·5	97·2

In the cases of the conversion of the rock into pipe-clay there are apparent losses of silica present as quartz as compared with the amount calculated to be present in the granite and the hornblende-granitite. This is due to re-arrangement of the material by washing, which has separated the finer particles from the coarser ones, which, as a rule, form coarse sands to fine angular gravel on the surface of the pipe-clay.

In the foregoing description of the British Guiana lateritic earths and their components, I have confined myself to the laterites which are in situ, and have not described the so-called low-level laterite or the "Alluviale Laterit or Sekundare Laterit" of G. C. Du Bois, which he defines as "Aluminous Laterit" or as the "Alluvium von Lateritdetritus". Where I have seen alluvial deposits of this nature in British Guiana they have been mixed to such an extent with the detritus from granitic rocks or even from clastic rocks that they have not, in my opinion, a right to the term laterite. But I have shown in connexion with certain of the laterites I have described how readily aluminous deposits can be formed from normal lateritic earths by ordinary processes of elutriation and redisposition. The accurate and complete account of the "Alluviale Laterit" of Surinam by Du Bois is fully applicable to those of British Guiana. But personally I do not apply the term laterite to these detrital deposits, which are equally well described as valley or river alluvia.

I have also not described the deepest layers of the residual deposits which are met with in the shafts of mines below the water-table and closely overlying the unaltered rock. They do not, as far as my limited experience goes, show the characteristics to any marked extent of laterite either according to Buchanan's description or to more recent views. They are best described as decomposed diabase, gabbro, or schists as the case may be, as they largely consist of partially decomposed fragments of these rocks with varying amounts of secondary quartz, hydrates of alumina and iron, and kaolinite derived in part from the decomposing rocks or washed in from overlying lateritic earths.

Where the original rocks are massive and compact, are only covered with comparatively thin layers of lateritic products, and are practically above the water-table, the transition from unaltered rock to lateritic earth is abrupt, and few, if any, particles of the original rock, except grains of ilmenite and of similar highly resistant mineral, can be found in the residual earths lying directly in the rock.

The Laterite of Surinam and of French Guiana.—The ferruginous residual earths in South America appear to have attracted the notice of geologists and mining experts in these countries from quite early periods; for example, amongst other early authors they are mentioned by J. B. Le Bland, *Description de la Guyane Française*, 1814; v. Eschwege, *Beiträge zur Gebirgskunde Brasiliens*, 1832; Schomburgk, *Reisen in Guyana und am Orinoko*, 1841; Heuser, *Beitrag zur Kenntnis des brasilianischen Küstengebirges*, 1858; Le Neve Foster, "Caratal Gold-field" (Q.J.G.S., No. 99, vol. xxv, pp. 340–2); and Tate, "Geology of Guyana Venezuela" (Q.J.G.S., No. 99, vol. xxv, pp. 349 and 350).

Among more recent works in which more or less detailed accounts of the laterites of Surinam and French Guiana are given are: Martin, *Reise nach Niederländisch-Westindien*, 1888; Levat, *Recherche et l'exploitation de l'or en Guyane Française*, 1898; Du Bois, *Geologisch-bergmännische Skizzen aus Surinam*, 1901; van Cappelle, *La constitution géologique de la Guyane hollandaise*, 1907; whilst the most complete account of the Surinam laterites is Du Bois' monograph *Beitrag zur Kenntnis der Surinamischen Laterit*, 1903, to which I have several times referred.

Unfortunately for the purposes of this paper the analyses given by the above authorities are more or less incomplete owing to the silica present in the form of quartz not having been determined separately from that present in the combined state. The analyses of "Roche à Ravet" given by Levat on p. 42 of his work show that, even if all the silica was present in the combined state, the samples from Maripa would have contained 7·6 per cent. and those from Awa

7·7 per cent. of alumina in the state of hydrate. In the majority of the analyses of concretionary ironstones given by Du Bois it is not possible to demonstrate the presence of free aluminium hydroxide, but his analyses of an alluvial one show that at least 5·2 per cent. of alumina is present in the form of hydrate.

The fact that bauxite or gibbsite is found in the laterites of Brazil and of the Guiana has been known for many years. R. Hermann, in 1869 (*Journal f. prakt. Chemie*, vol. i, p. 72), described hydrargillite which occurred in the laterite of Villa Ricca in Brazil, whilst its occurrence in French Guiana was recorded in 1878 by Jannetaz in the *Bulletin de la Société Minéralogique de France*, vol. i, p. 70. The first full description of typical bauxitic laterite from Surinam is that given by Du Bois, pp. 34–7 of his monograph on the laterite of that colony. He there gives the following 'technical' analyses:—

Table XXIV.

	X	XI	XII
Alumina	63·3	48·5	52·5
Iron Peroxide	10·5	21·6	14·4
Silica	7	14·5	3·1
Calcium Oxide	1	1	1·5
Water	17·6	14	27·6
	99·4	99·6	99·1

Du Bois specifically states that the silica is present in them in the form of secondary chalcedony. If all of it is so present the bauxite contains from 48·5 to 63·3 per cent. of free alumina or from 62·5 to 80·9 per cent. of aluminium hydrate, whilst the lowest proportion of alumina that can be present in the uncombined state on the assumption that all the silica is combined with alumina will vary from 40 to 57 per cent.

The studies which have been made in the Guianas by Du Bois, Levat, Lungwitz, van Cappelle, myself, and others, both in the field and in the laboratory, show that certain residual deposits derived mainly from rocks of the diabase-gabbro, diorite, and porphyrite types which contain predominantly felspars of the albite-anorthite series have full right to be termed laterite both in the restricted sense of the term advocated in this journal by Dr. Evans and Mr. Crook and in the wider meaning originally ascribed to it by Buchanan; that masses of bauxite occur in residual earths of complex composition which cannot be described as characteristically aluminous, as they are usually to more marked extents siliceous or ferruginous, although they invariably contain more or less hydroxide; and that the concretions in the residual earths vary from concretionary ironstones to impure ferruginous bauxite.[1]

I have only seen the laterite in one district of Surinam where it formed a covering to a greatly metamorphosed sericitic schist. 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,

[1] In the Guianas the formation of masses of bauxite appears to be due to later segregation changes in the metasomatic residual earth rather than to the completeness of the original decompositions.

reminded me of Logan's account of the ferruginous and silico-ferruginous rocks and laterite of Singapore (Q.J.G.S., vol. vii, p. 331, 1851), and of Mr. Scrivenor's description of the laterite of the Malay Peninsula (Geological Magazine, September, 1909, No. 543, p. 431).

The view that I have formed after many years' fairly intimate acquaintance with the Guiana residual deposits in the field and in the laboratory is that the terms laterite or lateritic earths are both useful and convenient ones to denote the whole mass of the residual deposits which are characterized by the occurrence in them of concretionary masses varying from highly ferruginous to highly aluminous, as well as, in places, by the presence of secondary silica in quantity. In my opinion laterite of the above nature can be accurately defined, following Du Bois (p. 3 of his monograph), as the weathering product of igneous or metamorphosed rocks in which by chemical decomposition the silicates contained in them have been changed to secondary siliceous compounds, secondary silica and alumina, and to oxides of iron in more or less hydrated forms. Following Mr. Scrivenor the laterite can be conveniently classed into siliceous, ferruginous, or aluminous laterite as its composition indicates, whilst the highly aluminous masses present in them can, in my opinion, be best and most accurately described as bauxite. The above definition would cover not only the aluminous masses to which it has recently been proposed to restrict the term laterite, but also the great majority of these which possess, in parts at any rate, that property of setting from which the name was originally derived. It would also cover the residual lateritic deposits of varying compositions, due to climatic and other conditions, found in different parts of the Indies.

It is not possible in the Guianas to ascribe the production of lateritic deposits to regular alternation of dry and wet seasons. Du Bois gives a table in his work from which I have calculated in inches the average monthly rainfall in Paramaribo, Surinam, for the years 1896 to 1901. This and the average monthly rainfalls during sixteen years at stations in British Guiana situated on laterite are shown in the following:—

Table XXV.

	Surinam. Paramaribo. 1896–1901. Inches of rain.	British Guiana. Mean of 10 inland stations on Laterite. 1891–1906. Inches of rain.
January	5·24	7·06
February	5·61	4·29
March	8·65	7·22
April	8·39	8
May	12·25	11·89
June	11·65	12·45
July	6·37	10·69
August	5·49	7·96
September	2·66	5·22
October	3·45	4·23
November	7	6·57
December	5·49	10
	82·25	95·58

In the dense forests of the Guianas there may be said to be a perpetual wet season, as under the shade of the trees even during periods of comparative drought the land is invariably wet and more or less soaked with water containing organic acids in solution.

The only factor indicated in the Guianas as governing the production of lateritic deposits as opposed to that of pipe-clays is the original composition of the rocks. Rock in which plagioclase felspars with their usual concomitants of ferro-magnesian minerals are abundant, give rise by their decomposition in situ to laterite; those in which alkali felspars are predominant as a rule decompose to pipe-clays or kaolins.

The protective influence on the soils of the very heavy tropical forests which in the Guianas specially characterize the areas of lateritic residual deposits is very great. When the land is cleared of forest denudation rapidly removes the fine constituents of the earths, leaving on the surface the masses of ironstone, bauxite, and quartz. The Christianburg-Akyma deposits show that under conditions of which we have no indication a lateritic decomposition-product may differentiate into angular secondary quartz-sand and into concretions and impregnations of secondary hydrates of aluminium and iron.

It has been repeatedly stated that the production of laterite is confined to countries having hot, moist climates. Positive evidence as to this appears to me to be wanting. That the preservation of lateritic deposits is largely confined to more or less tropical countries I willingly admit, as it is the absence of frost that allows of the accumulation of deep deposits of laterite. The property of hardening or setting when exposed to the atmosphere which these deposits exhibit in parts, although sufficient for their protection under tropical conditions, would be of little effect were the deposits exposed to frost. Under temperate conditions the accumulation of laterite in situ to great depths would be more or less impossible; the residuary matters would be subject to rapid detrition and denudation, their hardening properties would not be developed or only to a slight extent, and what under tropical conditions would form laterite would be redeposited as alluvial detritus, in which the presence of free hydrate of alumina would not be easily recognized.

The majority of the analyses which have been made of such alkaline deposits have been for agricultural purposes, and in such analyses, unless the attack of the dilute acid used is continued for a great length of time, a considerable proportion of the alumina, which is in the form of hydrate, which is resistant to a marked degree to the action of weak acids, will not enter into solution and will be included amongst the sand and insoluble silicates. It is therefore possible that the proportions of alumina present as hydrate have been underrated in many analyses of the clays and earths of temperate countries, and that if analyses were carried out on lines adapted for the determination of the proportion of silica present as quartz, or colloid silica, and in the combined state and of the total amounts of alumina and other bases present, earths with noticeable proportions of other hydrates of alumina would be found not to be of rare occurrence. In connexion with the possible presence of alumina in the form of hydrate in the earths of temperate countries the investigations by Liebrich of the occurrences of bauxitic material in the Vogelberg and Westenwald (*Zeitschrift für Krystallographie und Mineralogie*, xxiii, p. 296, 1894, and *Chemisches Centralblatt*, 1892, p. 94), where the bauxite was proved to be a decomposition-product of a basaltic rock, and the recent paper on the same subject by J. R. Kilroe (Geol. Mag., No. 534, p. 534, December, 1908), may be of interest.

My long experience in the Tropics with igneous rocks and their decomposition-products has satisfied me that all questions relating to the degradation of the rocks and the re-arrangement of their decomposition-products may be accounted for by the normally occurring, practically unlimited factors of water, carbonic acid, decomposition-products, including organic acids of vegetable debris, and, above all, duration of time. Geologists and possibly chemists are apt to underrate the decomposing, ionizing, or mass action exerted by even pure water on rocks during very prolonged periods of time—periods which on the geologically very ancient land of the Guianas may have extended over geological ages.[1]

There is no necessity for calling in the aid of the very small quantity of nitric acid supplied by the rainfall, which in British Guiana has amounted to only 9 pounds of nitric acid (HNO_3) per acre per annum according to our monthly analyses of the rainfall carried on continuously for over twenty years. Nor are the small quantities of sulphuric and sulphurous acids derived from the oxidation of pyrites of importance, as in British Guiana pyrites is only present in appreciable quantity in metamorphosed rock, whilst in masses, dykes, and sills of diabase on which wide areas of laterite occur, its presence is practically confined to narrow selvages of the contact rock in even minute quantities.

As far as the studies made in the Guianas go it appears that the cause of the hardening or setting of certain laterites will not be found by chemical analysis. My personal opinion is that it is due in part to changes in the degree of hydration of the hydrated oxides of iron

[1] Some ten or eleven years ago, whilst lecturing on agricultural science, I used the following experiment to illustrate the action of pure water on rock. Rock powder was prepared from various types of rock by grinding on a bucking plate. About twenty grams of the rock powder was placed in a beaker, and from 100 to 150 cc. of cold, recently distilled water poured on it. To the water thus freed from carbonic acid a few drops of a solution of phenol-phthalin was added. In the course of a few minutes the water commenced to change to purple, and after ten minutes or so had elapsed the depth of colour produced served as a measure of the rates of decomposition of the various rocks by the water. I found that the most readily decomposable rocks were felspar-porphyry and porphyrite, the next being granitite-gneiss, followed by granite and granitite. The basic rocks were more slowly attacked by the water. After standing for some time when the colour of the water had ceased to deepen it was then poured or filtered off completely, the rock powder again treated with fresh quantities of the boiled water or in phenol-phthalin, when the gradual colourization again ensued. This, if desired, could be repeated many times, using the same rock powder. The experiments well illustrated the action of water free from carbonic acid on the rocks, and its repetition with successive quantities of water show it to be a mass action. The rates of decomposition of the various rocks thus indicated were found to correspond with the extent of their denudation and degradation on the lower-lying lands of the colony.

and aluminium present and to the gradual conversion of soluble colloidal forms of alumina, of iron peroxide, of silicate, and possibly of certain silicates with insoluble modifications during the exposure of the rocks to the atmosphere. The deposition of the hydrated oxides of iron from the dissociation of naturally produced solutions of carbonate of iron is doubtless in many places also a factor in the induration of the laterite in situ.

Weathering and Decomposition of Rock and Soils in the Tropics.

In his investigations on weathering of rocks in the Tropics, Mr. E. C. J. Mohr (Bul. Dept. Agr. Indes Neerland, No. 32, pp. 26, figs. 2, 1909) records the effect of rain-water on freshly ground Tertiary basalt under moist warm climatic conditions as follows:—

The rock was used in three sizes, $\frac{1}{3}$ to $\frac{1}{2}$, 1 to $1\frac{1}{2}$, and 3 to 4 mm. particles. It was subjected to the action of rain-water from July, 1906, to December, 1908, in an apparatus so arranged that in one series the level of the water was above that of the rock particles, and in the other the particles were kept moist by rise of water from below. The principal fact noted in the first series was that the silicic acid corresponding to the decomposed augite and lime felspar was washed out with the soluble bases, while the silicic acid corresponding to the alkali felspar remained behind as kaolin. In the second series, only the silicic acid corresponding to decomposed augite was removed, and the silicic acid corresponding to lime felspar remained behind. (Experiment Station Record, vol. xxii, No. 8.)

Note. Owing to a copyist's error, the figures 8·26, against "Iron Protoxide", incorrectly appear in the analysis of the Tumatumari Laterite (in Table IV on p. 446 of the October number of the Geol. Mag.), and should be deleted, the summation of the analysis being carried out as 100·45, the correct figures.

VI.—On the Classification of the Lower Carboniferous Rocks.

By Cosmo Johns, M.I.Mech.E., F.G.S.

In this communication it is proposed to briefly note the divisions which have been proposed for the Lower Carboniferous Rocks of Great Britain and Belgium; to discuss their validity in the light of the important additions that have been made to our knowledge during the last few years; and to suggest a new classification which, while expressing the physical and faunal changes which characterized that particular time interval, shall be generally applicable and at the same time do justice to the workers who have contributed most largely to our knowledge.

It will be necessary to clearly define what is meant by the Lower Carboniferous. In Staffordshire, Derbyshire, and North-West Yorkshire the line has been drawn at the base of the Ingleborough or Kinderscout Grit or its equivalent. In Scotland the Roslin Sandstone is the dividing line, and in the first and last of the areas mentioned Mr. Kidston[1] has determined the great break between the Upper and Lower Carboniferous Floras to take place at this level. In Derbyshire and North-West Yorkshire a marked change of conditions occurs at the same level, and the Geological Survey in both places drew the line at the base of the massive Grit. By definition, therefore, Lower Carboniferous extends up to the level where the plant break occurs. No one has suggested extending the limits any higher, and to draw the line at a lower level would divorce the Upper Yoredale limestones with their rich coral and Brachiopod fauna from the lower limestones

[1] See Mem. Geol. Surv. Derby. and Notts. Coal-field, 1908, p. 9.

with which they are faunally and physically linked. There should be no difficulty in selecting a name for this great division of the Carboniferous System. The work that has been done by Dr. Arthur Vaughan on the Avon section, and the impetus which the publication of his conclusions gave to the study of the Carboniferous Limestone in this country and abroad, at once suggests the acceptance of the term AVONIAN in preference to Bernician or Dinantian.

For the divisions of the Avonian we have in common use the terms Tournaisian and Viséan. If only in fairness to the Belgian workers who established these divisions, and in recognition of the value of their contribution to our knowledge, these terms should be retained. It has been demonstrated [1] that the line drawn in Belgium corresponds exactly to the physical break in South Wales at the base of the Viséan, and is the well-known C–S level of North-West Yorkshire and Westmoreland. Thus the dividing line between Tournaisian and Viséan is, and can only be, drawn at the same horizon in these widely separated areas.

It is not so easy to define the upper limits of the Viséan, for the Avonian coral and brachiopod fauna persisted longer in some districts than others, but over wide areas it gave place, as a result of physiographic changes, to a new fauna, chiefly cephalopods and lamellibranchs, which persist to the summit of the Lower Carboniferous. It is to Dr. Wheelton Hind we owe the demonstration that this fauna which characterizes the Lower Culm is the same as that of his Pendleside Series. Viséan cannot be made to include this Culm or Pendleside fauna, which can be seen in Derbyshire, Yorkshire, and Lancashire to succeed it.

<table>
<tr><td>Upper Carboniferous.</td><td colspan="4">Level of the Plant break.</td></tr>
<tr><td rowspan="4">Lower Carboniferous.</td><td rowspan="4">AVONIAN.</td><td rowspan="2">Yoredalian</td><td>Upper</td><td>Upper Yoredale Coral Fauna.</td></tr>
<tr><td>Lower</td><td>Entrance of Lower Culm or Pendleside fauna (Posidonomya Becheri).</td></tr>
<tr><td>Viséan</td><td colspan="2">Entrance of C–S fauna (Caninia patula, Clisiophyllum Ingletonense).</td></tr>
<tr><td>Tournaisian</td><td colspan="2"></td></tr>
</table>

The difficulty, however, has been to determine the relationship between the Yoredale rocks of the typical Yoredale district and the Pendleside Series. Reasons have been given [2] for correlating the *Posidonomya Becheri* beds of the Pendleside Series with the Lower Yoredales, and it might be further pointed out that the coral fauna of the Upper Yoredale limestones is an appreciable advance on the D_2 of South Wales. Perhaps even more important is the fact that at the

[1] Arthur Vaughan, Brit. Assoc. Reports, Carboniferous Fauna, 1910.
[2] Evidence for this will be given in the *Naturalist*, January, 1911, p. 9.

top of the Viséan there occurs a well-marked *Cyathaxonia* phase which is generally succeeded by the *Posidonomya Becheri* beds. In the typical Yoredale area the same succession has been observed at the base of the Yoredales. If the equivalence of the Lower Culm, Pendleside, and Yoredale Series be admitted, then a tripartite division of the Avonian is necessary, and for this upper division the work of Phillips in having pointed out the importance of the Yoredales as a distinct division of the Lower Carboniferous should be recognized, and the term Yoredalian employed in our proposed classification, shown on p. 563.

It is obvious that with any classification there will be local difficulties. It is known that in some places the normal D_2 conditions persisted into Lower Yoredale time, or that it was replaced by a development of the 'knoll' limestones. In other areas the *Cyathaxonia* phase is found intercalated with the *Posidonomya Becheri* beds. These difficulties are but local and do not affect the general applicability of the proposed classification.

REVIEWS.

I.—A Descriptive Catalogue of the Marine Reptiles of the Oxford Clay, based on the Leeds Collection in the British Museum (Natural History), London. Part I. By Charles William Andrews, D.Sc., F.R.S. 4to; pp. xxiii and 205, with frontispiece, 10 plates, and 94 text-figures. Printed by order of the Trustees of the British Museum, London, 1910. Price £1 5*s*.

FOR some years past visitors to the Natural History Branch of the British Museum at South Kensington, who have passed through the gallery devoted to fossil reptiles, cannot have failed to be attracted by certain specimens of Plesiosaurians which, on account of their perfect condition and the method of mounting, appear more like modern skeletons than the remains of ancient fossil creatures. These specimens, it is well known, form part of the famous Leeds Collection of fossils from the Oxford Clay of Fletton, near Peterborough. It was Dr. Henry Woodward, when Keeper of the Department, who first interested himself to obtain these remarkable specimens for the British Museum; and his successor, Dr. A. Smith Woodward, has been no less assiduous in securing this unique collection.

It is now several years since the first of the skeletons was placed on view in the Museum cases, and it had been mounted most skilfully and with great patience by the late Mr. C. Barlow. Several other examples have been added more recently, most skilfully set up by his son, Mr. F. O. Barlow, the present formatore. A careful examination of these specimens, even by those who are not specially interested in fossil reptiles, will prove of no little interest, especially if one bears in mind the amount of time, attention, and skill expended in bringing them into their present satisfactory condition.

The greater number of the bones were obtained by Mr. Alf. N. Leeds, of Eyebury, Peterborough, during the last twenty years, but the collecting was begun much earlier by his brother, Mr. Chas. E. Leeds. Mr. Leeds, living near the Oxford Clay pits at Fletton and other localities near by, had unusual facilities for obtaining the fossils which were unearthed, and lost no opportunity of rescuing them; the greatest care being taken by him to keep the various parts of each individual together and separate from others. The bones were numbered and packed in separate parcels, so that in the end it has been possible to bring together the almost complete skeletons of a number of these animals. Frequently the bones when found were broken in many pieces, and these were reunited by Mr. Leeds with the greatest skill and patience. Subsequently, when the specimens came into the possession of the British Museum, they were mounted with no little ability by the formatore in the Geological Department, and now several of them are to be seen in the Museum cases. Those of us who have examined these wonderfully reconstructed skeletons have long been hoping for some account of them, and at length we have the satisfaction of welcoming the volume which has been published by order of the Trustees of the British Museum, and proves to be a memoir worthy of the institution from which it issues. The work is entitled *A Descriptive Catalogue of the Marine Reptiles of the Oxford Clay*, but although this title may be correct it conveys but little idea of the careful and detailed labour which has been bestowed upon the volume by Dr. Andrews. It is an elaborate memoir, and will in future be the necessary work of reference for the Oxford Clay reptiles of which it treats.

Dr. Andrews, in his Introduction, gives an interesting general account of the collection, and says the perfection of some of the specimens is such that "it has been possible to mount the bones in their natural relations as easily as if they had been obtained by the maceration of a fresh carcass". "A notable instance of this is the fine skeleton of *Cryptocleidus oxoniensis* which is figured on the Frontispiece," reproduced from a photograph. Skulls, it seems, have rarely been found in anything like a perfect condition, and frequently some part of a skeleton, such as a limb, is wanting in an otherwise perfect specimen; from these and similar facts it is argued that many of the bodies must have been dismembered while the bones were still united by the softer tissues. A short account is given of the geological horizon that has yielded this collection of fossils, which is said to be the Lower Oxford Clay of English geologists, characterized by numerous examples of the 'Ornatus' group of Ammonites.

The present volume is only the first part of the entire work, and is restricted to the description of the Ichthyosaurian and Plesiosaurian remains; while Part II, we are promised, will deal with the Pliosaurs and Crocodiles.

The Ichthyosaurian specimens are all referred to one genus and one species, *Ophthalmosaurus icenicus*; and it is pleasing to find that these names, proposed by the late Professor H. G. Seeley (thirty-six years ago), can be retained for them: his keen insight into the details of reptilian osteology enabled him to realize the importance of characters which are still used for their generic distinction. Although only one Ichthyosaurian species is recognized by Dr. Andrews in the present work, he appreciates the large amount of variation to be seen in different skeletons; due to some extent, no doubt, to age and various stages of ossification, as well as to conditions of fossilization: and he makes the pertinent observation that "If only a few skeletons had been preserved several forms would probably have been recognized and named". But with so large a series before him "it has been found impossible to distinguish more than a single species". Few geologists will be inclined to find fault with this specific restriction, although "future investigations may render possible the diagnosis of others".

The restoration of the cranium of *Ophthalmosaurus* has been an exceedingly difficult matter, seeing that it was largely cartilaginous, and consequently the bones show few or no sutures, or surfaces of actual contact; indeed, but for the fact that in this collection of fossils only one Ichthyosaurian genus seems to be represented, it would have been a wellnigh hopeless task. Numerous specimens, illustrating all parts of the skeleton, are described in detail, and after a short account of the species there follows a catalogue of the very numerous specimens preserved in the Museum.

The Plesiosaurs all belong to the one family of the Elasmosauridæ, characterized chiefly by the scapulæ meeting in a median symphysis which is continuous with the symphysis of the coracoids: and the scapulæ grow inwards (in front) below the clavicles and interclavicles. The clavicular elements become more or less reduced, and it is the variations in this reduction which supply some of the chief characters for the distinction of different genera. Four genera of Elasmosauridæ are recognized: *Muræenosaurus*, with three species; *Picrocleidus*, with two forms, only one of which is specifically named; *Tricleidus* and *Cryptocleidus*, each with one species. Of these four genera two, *Muræenosaurus* and *Cryptocleidus*, were so named by Professor Seeley, the first in 1874 and the other in 1892; while *Picrocleidus* and *Tricleidus* are genera established by Dr. Andrews quite recently.

The most perfect specimen in this collection is, perhaps, the *Cryptocleidus oxoniensis*, already mentioned as being mounted in the Museum and figured as the frontispiece; and this species has an additional interest inasmuch as it was first described by Professor Phillips in 1871 in his *Geology of Oxford.*

Each genus is separately discussed by the author, and numerous specimens described in detail: the various parts of the skeleton, skull, vertebral column, pectoral and pelvic girdles, and limbs being treated separately and illustrated by plates and text-figures. Following the description of each genus is a brief account of the species referred to it, and a catalogue of the specimens preserved in the Museum.

The volume is liberally illustrated, for besides the frontispiece there are ten lithographic plates and ninety-four figures in the text. Eight of these plates have been drawn by Miss G. M. Woodward with her usual care and artistic finish, and two are the work of Mr. A. H. Searle and are equally worthy of commendation. The text-figures leave nothing to be desired in the way of clearness; but, like so many text-figures in present-day publications, they are far from adding to the beauty of the page; many of them, too, are far larger than is necessary to show the required details; and might almost be called rough diagrams rather than figures which, while giving the necessary illustration, embellish the page. Modern process-blocks are far from having attained to the perfection which is to be found in many of the old-time woodcuts.

It will be eminently pleasing to palæontologists and, indeed, to all scientific workers to know that the Trustees of the British Museum have added this *Descriptive Catalogue of the Oxford Clay Reptiles* to the long list of their admirable publications. We await with some impatience the publication of the second volume; and in the meantime congratulate Dr. Andrews on this most successful completion of the first part of his valuable work.

E. T. N.

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

The Geology of the London District (being the area included in Sheets 1–4 of the special Map of London). By Horace B. Woodward, F.R.S. London: printed for H.M. Stationery Office, and sold by E. Stanford, Long Acre, and T. Fisher Unwin, Adelphi Terrace. 8vo; pp. viii and 142, with a small contour-map of the London District. Price 1*s.* Sheets 1–4, price 1*s.* 6*d.* per sheet. 1909.

THIS memoir was issued early in the present year (1910), and is intended to carry on *The Guide to the Geology of London and the Neighbourhood*, prepared by that indefatigable geologist Mr. Whitaker and published in 1875. That work reached its *sixth* edition in 1901, and is now out of print. The four-sheet map now issued, printed in colours (which is less expensive and slightly smaller than that published in 1903), is largely founded on Mr. Whitaker's work, and also on subsequent work by Horace B. Woodward and other members of the Survey.

"No one," says Dr. J. J. H. Teall, "can write on the geology of the neighbourhood of London without being indebted to the work of the late Sir J. Prestwich and of Mr. Whitaker. In the early memoir on *The Geology of the London Basin*, and in the two volumes on *The Geology of London*, Mr. Whitaker not only recorded all the facts gathered during the progress of the Geological Survey, but dealt fully with the observations of other geologists, adding his own criticisms on divergent views . . . Though no effort has been spared by Mr. [Horace] Woodward to acknowledge the sources of information, it has proved to be impossible to do justice to the voluminous literature within the limits of so small a memoir."

The four new sheets which the memoir is intended to explain and describe have each an *inside* coloured area of $18\frac{1}{4}$ inches by $12\frac{1}{4}$ inches, with explanation of colours and formations on their outer margin, the scale given being 1 inch to 1 statute mile, their united surfaces covering an area of $36\frac{1}{2} \times 24\frac{1}{2}$ miles. They are called "Drift Maps", but they really show the extent of the strata or *geological formations* which occur immediately beneath the soil. As examples we may mention the Thames Valley Gravel, the Bagshot Sand, the Thames Valley Brickearth, the London Clay, the Boulder-clay, the Chalk, and the Peat which occurs in the Alluvium of the Marshlands.

"The Chalk forms the foundation of the entire area. It is followed by the Eocene Series, which is represented in and around London by the Thanet Sand and higher divisions up to the Bracklesham and Barton Beds. This series occupies a shallow trough formed by the uplift and bending of the great mass of Chalk so as to constitute what is known as the London Basin; and thus it covers the Chalk from Dartford and Croydon on the south-east to Watford and Rickmansworth on the north-west . . . It is with the Subsoil, not the Soil, except in the case of artificial accumulations of Made Ground, that the Architect, Physician, and the House-Hunter are concerned." (p. 2.)

"The story of London is usually reckoned to commence less than nineteen hundred years ago, when the Britons, who had established a kind of fortified settlement on the rising ground now dominated by St. Paul's Cathedral, were displaced by the Romans (A.D. 43) . . . The Holbourne or Fleet Stream occupied the valley to the west, and the lower part of its course was tidal; while the Wallbrook entered the Thames on the east, above the reach known as 'The Pool'." (p. 3.)

Although on a very reduced scale, the small contour-map which accompanies the memoir gives an exceeding clear idea of the hills, valleys, and streams of the London area, from Rickmansworth in the west to Brentwood in the east, and from Barnet and Enfield in the north to Ewell and Shoreham in the south. An ideal valley, well suited to the needs of its vast population, fed by innumerable streams of sweet water rising from the high grounds north and south, and which, but for the insanitary habits of its mediaeval and later inhabitants, might, as my old friend Dr. G. V. Poore [1] pointed out, have remained in sight the joy and glory of London, but, through constant pollution, they had compulsorily to be put underground, where they still flow in our sewers, serving as our unseen benefactors and sweetening the evils of life.

The history of underground London, geologically speaking, takes us far below the greatest depths of sewers or tube-railways, but is only known through the all too few experimental artesian borings which have been made in various parts of the area of greater London, commencing with the historic Kentish Town boring reported upon by Professor Prestwich [2] and later on by Mr. Godwin-Austen,[3] which reached a depth of 1,302 feet. 188½ feet of red and mottled clays, sands, sandstone, and conglomerates were proved, but their age is uncertain, although most probably Palæozoic. Undoubted Devonian fossils were obtained from a boring at Meux's Brewery, Tottenham Court Road, 1,066 feet from the surface. At Richmond Professor Judd records that fragments of anthracite mingled with Coal-measure sandstone and other Palæozoic rocks were found in considerable abundance, so that we may conclude that the coal under London has really been found, though not in situ.[4]

[1] *London Ancient and Modern, from a Sanitary and Medical Point of View*, by G. V. Poore, M.D., F.R.C.P. (Cassell & Co., 1889), 8vo, pp. 6 and 128.

[2] Q.J.G.S., 1856, vol. xii, pp. 6–14 (1855).

[3] Q.J.G.S., 1856, pp. 38–73; also Proc. Roy. Inst., vol. ii, p. 511. Mr. Godwin-Austen wrote on the boring at Meux's Brewery, Geol. Mag., Dec. II, Vol. IV, pp. 474–5, 1877.

[4] Q.J.G.S., vol. xl, p. 760, 1884.

A boring by the New River Company at Turnford, near Cheshunt, reached Silurian strata at 796 feet.

At Crossness 52 feet of hard red and grey micaceous and quartzose rocks, red shales, and grey sandstones were met with (suggestive of Devonian rocks), but no fossils are recorded.

At Streatham boring 138 feet of reddish and purplish sandstones of New Red (or possibly Devonian?) age were passed through. Some of these doubtful red rocks may prove to be stained Carboniferous strata, as suggested by Mr. Whitaker.[1] These borings have also yielded rocks of Great Oolite age.

"Thus we find at a depth of 1,000 feet and more under London strata the representatives of which come to the surface about 100 miles distant on the west. There is evidence, however, that the Jurassic strata occur under London in the form of a denuded anticline, as on the west and north-west the Kimeridge Clay, Portland and Purbeck Beds, are the nearest of the exposed Jurassic rocks; on the east, beneath Chatham, the Oxford Clay has been reached, and on the south-east higher Jurassic divisions occur. No representatives of the series are present below Crossness." (p. 8.)

In short we find that the synclinal fold of Cretaceous rocks in which the London Tertiary basin lies, rests upon a denuded anticline of older Secondary rocks whose base consists of Palæozoics of Carboniferous and in part of Devonian and even Silurian strata.

Fifteen sections in the text and a contour-map, with a general geological section showing the relations of the rocks along a line across the London Basin from Watford to near Shoreham, serve admirably to illustrate the Cretaceous and Tertiary Series and their distribution at the surface over the London district as set forth by the author in Chapters III and IV, whilst the faults and disturbances to which these formations have been subjected are described in Chapter V. The surface configuration marked by the Pliocene and older Drifts are considered in Chapter VI, and the Pleistocene and newer Plateau Drifts and Glacial Deposits in Chapter VII. More attention is given to the contours which affect the water-partings and the river-courses, in illustration of which a useful little map by Mr. A. Strahan is introduced on p. 62 to show the Thames and its affluents from the Cotteswolds to the Nore.

The Plateau and Valley Gravels and the Terraces along the river-course have furnished a very interesting chapter in the history of early Man in the Thames Basin (Chapter VIII). We obtain exact evidence of Man in the Palæolithic age, by his various types of flint implements (see figs. 13–16, pp. 79–80), from the high and low level gravels corresponding in relative antiquity with those of La Madélaine, Solutré, Le Moustier, St. Acheul, and from Chelles (Seine-et-Marne) in the French caves and gravel deposits. Moreover, their occurrence has been observed for more than 200 years, "a British weapon found with Elephant's tooth" having been dug up in Gray's Inn Lane about 1690 and since preserved in the British Museum (p. 79). Added to the flint implements left by early Man, as evidence

[1] Address to the Geological Society, Q.J.G.S., vol. lvi, p. 83, 1900.

of his residence in the Thames Valley in prehistoric times, we are also furnished with a long list of the animals (thirty-five are recorded) which he saw and hunted (pp. 76–7), most of which are now extinct or are no longer living in Britain, but which were then indigenous to the London district. In Chapter IX the Holocene or Recent deposits are described, and much interesting information is given as to the wild Mammalia which had their home around British London and in Roman and later times. Some twenty-four species are recorded on pp. 99–100.

Water supply is not neglected (see Chapter X), and some very interesting records are given of old sources of supply. The Metropolitan Water Board have now to provide for a population of nearly seven millions of inhabitants at the rate of 30 gallons, or a little more, per head daily, the daily amount of water required being about 225 millions of gallons (p. 115).

The author in his conclusion reminds us that "the present diversified features are the result of a great series of changes of earth-movements, erosion, and deposition, accompanied by varying conditions of scene, climate, and life; and how the aspect of the country has been modified in later times by the agency of Man. . . . We have further shown how the geological structure has influenced the water supply, and how the different strata have yielded materials of economic value, conducive to the well-being of the community" (p. 132).

We congratulate the author (Mr. Horace B. Woodward), who has followed in the steps of his predecessor (Mr. W. Whitaker) and has produced an excellent and useful memoir upon the area of the greatest and most populous city on the globe. The maps specially deserve commendation, and the price of the maps and the memoir are both extremely moderate.

III.—An Introduction to Petrology. By F. P. Mennell, F.G.S. 8vo. London: Gerrards, Ltd.

THIS little volume of some 200 pages presents an attractive appearance, and in its internal arrangement gives evidence of much thought and an acute appreciation of some of the difficulties which beset an elementary student of petrology. The plan of the work is distinctly good, but unfortunately the chapters do not fulfil the promise of their headings. The first half of the book, which deals with general principles and rock minerals, is the weaker portion, and it is evident that the second half, which treats of rocks and rock structures, was that part of the work with which the author was most at his ease.

It is to be regretted that the earlier portion does not fulfil the purpose that the author intended for it; had it done so, the volume as a whole would have formed a self-contained and most useful guide to the microscopical study of rock-forming minerals and rocks.

In reading the earlier chapters it is impossible to pass without comment such statements as the following, which, if not quite incorrect, must at any rate lead to much confusion. On p. 25 he says: "Every mineral refracts light to a certain extent, that is to say, makes light deviate from a rectilinear path in passing through it. Now on the undulatory theory light is composed of vibrations of the ether in all possible directions. When, however, it passes through a crystal belonging to any other than the regular system all the vibrations are made to take one or other of two definite directions at right angles to each other and to the direction of propagation. The light is then said to be polarised." There is also much confusion in the use of the terms 'refractive index' and 'indices'. Again, on p. 31 he says: "The mica gives a typical biaxial figure showing two dark hyperbolæ (brushes), which unite four times during a rotation (at the extinction positions) to form a cross of which one arm is broader than the other. The thin arm joins the optic axes. The broad arm is called the bisectrix, in the case of mica the acute bisectrix as it bisects the acute angle between the optic axes." On the following page, speaking of the optical sign of minerals, he remarks: "Some minerals have their interference tints heightened when covered with a quartz wedge having its long axis in the same direction as their own, while others have them lowered. In the first case the sign of the double refraction is said to be *positive*, in the latter it is *negative*." We are left to guess, however, what constitutes the 'long axis' of either the crystal or the quartz wedge. The whole of the introductory portion dealing with the crystalline form and optical properties of minerals is put into twenty pages, and is almost valueless to any serious petrological student. Chapters VII–XI deal with the rock-forming minerals, and these constitute a useful portion of the book. However, it would have been better if the minerals had been arranged according to their crystalline system or their optical behaviour rather than their chemical composition. Their descriptions are often somewhat unscientific, and occasionally there are insufficient data for the identification of a certain species. It is to be remarked that such valuable mensurate constants as the bi-refringence in anisotropic media are disregarded. Chapters XII–XXI refer to igneous and sedimentary rocks, and the processes and products of metamorphism and weathering. The description of the various simple rock types is by far the best portion of the work, but it suffers from incompleteness, and there is occasionally a lack of definition of rock names and structures. Many of the illustrations are admirable, especially those which are reproduced from line-drawings, but some of the photomicrographs are too smudgy and out of focus to be worth the space they occupy.

H. H. T.

IV.—Some New Geological Maps.

1. Geological Map of Egypt.—We have received from the Survey Department, Cairo, a geological map of the country issued 1910, in six sheets, on the scale of 1 : 1,000,000, on which the various formations are very clearly shown in colour-prints. No record, however, appears of the names of the geologists who are responsible for the field-work. The area extends from the Gulf of Salum and Alexandria to Port Said on the north, and from Wadi Halfa to Ras Hadarba on the Red Sea coast on the south. The southern part of

the Sinai Peninsula is also coloured geologically. Notes of mines and quarries are printed on the map, and the "Gravel Ridges of Quartz and Chert Pebbles with Silicified Trees" are indicated in the Oligocene tract west of Cairo. The famous "Petrified Forest" that occurs to the east-south-east of Cairo occupies a comparatively small area and is not marked. Some account of it was given by Mr. Carruthers in the Geological Magazine for July, 1870 (p. 306).

Another geological map of Egypt, in one sheet, scale 1 : 2,000,000, has also been published by the Survey Department.

2. Oxford Wall Maps.—A series of wall-maps designed to assist teachers of Geography is in course of preparation and publication at the Clarendon Press, Oxford, under the editorship of Professor A. J. Herbertson. The maps are not simply reproductions of existing works, but have been specially prepared with the aid of experts, and drawn by Mr. B. V. Darbishire, M.A. Most of the maps are to be printed without names of places, etc., as these obscure the main features. Such is the case with the specimen before us, "The British Isles, Geology." The scale is 1 : 1,000,000 or about 16 miles to 1 inch. Squares printed in black, alongside the scale, show respectively areas of 250 square miles and 100 square kilometres. The geological groups that are indicated by colour on the map are Igneous, Archæan, Cambro-Silurian, Devonian–Carboniferous, Permo-Triassic, Jurassic, Cretaceous, and Tertiary. Coal-measures are printed in black, and the other Carboniferous strata are distinguished from Devonian by cross-ruling. Magnesian Limestone, Oolite Limestone, and Chalk are indicated in a general way by cross-ruling. The colour-printing is clear, and although there are some slight differences in shade between the northern and southern halves of the map (which have been separately printed), they are hardly noticeable at a distance. The map, which includes the adjacent portions of France and the Channel Islands, should be a very useful diagram to a teacher versed in geology, especially if provided also with a map of the physical features and a series of geological sections. The price of the geological map is 7*s.* unmounted, 8*s.* 6*d.* mounted on cloth to fold, and 10*s.* 6*d.* on rollers.

REPORTS AND PROCEEDINGS.

Geological Society of London.

November 9, 1910.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Rhætic and Contiguous Deposits of West, Mid, and Part of East Somerset." By Linsdall Richardson, F.R.S.E., F.L.S., F.G.S.

This paper contains a detailed account of the Rhætic strata of Somerset, with the exception of a small area bordering upon Bristol. The magnificent sections at Blue Anchor and Lilstock are described in detail, and correlated with those on the opposite Glamorgan coast. The record by Professor Boyd Dawkins of characteristic Rhætic mollusca in the top portion (uppermost 14 feet or so) of the Grey Marls is confirmed, and the contention for their recognition as Rhætic is fully substantiated. The deposit between the top of the fossiliferous Grey Marls or 'Sully Beds' and the main Bone-bed at Blue Anchor measures 22 feet, and teems with interesting Rhætic fossils, such as *Pteromya crowcombeia*, Moore. The beds above the Bone-bed agree very well with those occupying the same stratigraphical position in Glamorgan, and include the 'Upper Rhætic', the equivalent of the White Lias proper, and the 'Watchet Beds'. The now obscured magnificent sections, that were temporarily to be seen in the railway-cuttings at Langport and Charlton Mackrell, briefly noticed by Mr. H. B. Woodward, are described in detail (the records being made in company with Mr. E. T. Paris, F.C.S.). Here huge boulder-like masses of rock were noted at the top of the Black Shales, and the White Lias proper, with a well-marked Coral Bed, totalled 25 feet in thickness. The classic sections of Snake Lane, Dunball (Puriton), Sparkford Hill (Queen Camel), Shepton Mallet, and Milton (Wells), have been re-investigated and brought into line; and the interesting thin Rhætic deposits in Vallis Vale, at Upper Vobster, and sections in the Radstock district, and on the Nempnett and neighbouring outliers, are described. In addition to the record of many new or imperfectly known sections, this investigation has also shown that the *Micròlestes* Marls are equivalent to the Sully Beds: that the Wedmore Stone occurs well below the Bone-bed; that Moore's 'Flinty Bed' at Beer Crowcombe is probably on the horizon of the *Pleurophorus* Bed (No. 13); that the Upper Rhætic (generally with Cotham Marble or its equivalent) is as persistent as usual, if not quite so thick; that the White Lias proper is of restricted geographical extent; and that on the Bristol Channel littoral are marls, 'Watchet Beds,' above the White Lias. Around Queen Camel, Moore's 'Insect and Crustacean Beds' appear to come in at an horizon which lies between the Watchet Beds and the *Ostrea* Limestone.

The following classification of the Rhætic Series is suggested, and the succession of maxima of the characteristic fossils is given in the paper:—

			Thicknesses in England.
Lias.	Hettangian.	*Ostrea* Beds, etc.	
Rhætic	Somersetian	I. Watchet Beds ('Marly Beds of the White Lias')	0 to 7 ft. 7 in.
		II. Langport Beds (White Lias proper)	0 to 25 ft.
		III. Westbury Beds ('Upper Rhætic')	2 ft. 9 in. to 19 ft.
	Rhætian	IV. Lilstock Beds (Black Shales)	1 to (?) 47 ft.
		V. Sully Beds (Fossiliferous Grey Marls)	0 to 14 ft.
Keuper	Keuperian	Tea-green and Grey Marls . .	111 ft. (max.).
		Red Marls.	

The sudden lithic and faunal changes in the contiguous divisions are held to be the expression of oscillatory movements and interrupted sequential deposition. The fauna of the Rhætian is decidedly Swabian in facies, and the general conclusion to be derived from the study of the beds is in entire agreement with Suess's view, that while the dominant movement was one of subsidence and not local but extended, it was, nevertheless, "oscillatory and slow."

2. "Jurassic Plants from the Marske Quarry." By the Rev. George John Lane, F.G.S.

The Marske Quarry is situated on the northern side of the Upleatham outlier in the Cleveland district of Yorkshire. It is about 500 feet above sea-level. In the quarry several varieties of rock are exposed, namely shales, small coal-seams, sandstones, and a ferruginous bed. The beds are of Lower Oolite age, and belong to the Lower Estuarine Series. As the Millepore Bed is absent in the district, the Lower Estuarines and the Middle Estuarines may be one continuous deposit. From this quarry *Dictyozamites* was recorded for the first time in England, its occurrence being made the subject of a paper presented by Professor Seward to the Geological Society in 1903. The writer has obtained nearly forty species from the quarry, among which are many characteristic Wealden plants. This discovery is most interesting, especially when one considers the vast interval of time that elapsed between the horizons of the Inferior Oolite and the Wealden.

CORRESPONDENCE.

THE ORIGIN OF THE BRITISH TRIAS.

Sir,—In reply to your correspondent Mr. W. B. Wright,[1] of the Scottish Geological Survey, who has doubtless heard much of the Desert theory from his former colleague, Mr. T. O. Bosworth (who has so ably described the evidences of desert conditions in Leicestershire), Mr. Wright must know that it is unusual to criticize an abstract[2] before the full text of the paper is printed. I shall therefore be as brief in my reply as I was in the abstract, only quoting the numbered passages from Mr. Wright's letter. I may reply—

(3) I do not speak of a general absence of delta-bedding, for see (9). It *does* occur. Professor Bonney is cited by me as proving the delta origin of the Bunter, and I do not propose here to add one iota to his evidence. It is quite clear enough, and the Survey Library contains the papers in which Professor Bonney published his proofs. The dactyloid form is just a further point of analogy, and the extension of the Trias delta-head is suggested by evidence from deep borings (as to which let Mr. Wright ask Mr. Whitaker, who will also give him all the bibliographical assistance he needs, as he kindly did for me) in the East and South-East of England, chiefly made in connexion with explorations for coal.

(9) It would be equally as fruitless as trying to find the river-bed of the Triassic delta (or its tributaries) to expect to show beds in the act of tilting through an angle of 45°; but it is an axiom of modern physical geography (which I merely extend to the past) that beds when subsiding do tend, when so elevated, to become horizontal finally. The discontinuity of delta-bedding, laterally and vertically, seen so clearly in Staffordshire and Notts., is an ocular demonstration of what has happened in the past; but no more is to be expected. The characteristic overlapping, of which Mr. Wright must have

[1] See Geol. Mag. for November, 1910, p. 526.

[2] See "Origin of the British Trias", by A. R. Horwood (Abstract of paper read at the British Association, Sheffield, September, 1910): Geol. Mag., October, 1910, p. 460.

seen something in Notts., gave rise in early Survey days to the interpretation of certain sections of strata so juxtaposed as faulted beds. Viewed as delta-bedded deposits the faults disappear, and such instances can perfectly well be illustrated on a map just as the discontinuous bedding.

(16) Rocks polished by wind-action occur at various points at Mount Sorrel, Croft, and elsewhere. These older pre-Triassic rocks are at practically the same level as O.D., and the Trias was laid down just as we now find it, with a slight dip, allowing for subsidence. It is merely a *petitio principii* to say cases for observing wind-polishing are very exceptional. But it is very damaging evidence for the desert theory to show that this action occurs only where red marl abuts against older rocks *and along a single horizontal line.* This illustrates the local (littoral or marginal) character of desert action in Triassic times.

(20) A reference to Professor Hull's Survey memoirs and Professor Bonney's papers will give Mr. Wright the information he desires.

(21) The nature of the heavy minerals of the Bunter, Keuper, and the Nile indicates that they have a common character and in their several areas a common origin to a great extent. It is known that the Nile delta deposits are mechanically altered, owing to their having been, in part, derived from a contiguous desert. In the Nile the water is free from those chemical agents which ordinary river- or rain-water contain, so that chemical action is absent. In the Trias river and rain have acted in such a way during the past that the marls of the Upper Keuper exhibit their effect. This point is another corroborative of the aqueous origin and, together with other indications, of the delta origin of the Trias.

A. R. Horwood.

Leicester Museum.
November 14, 1910.

OBITUARY.

JOHN ROCHE DAKYNS, M.A.

Born January 31, 1836. Died September 27, 1910.

J. R. Dakyns, the eldest son of Dr. Thomas Henry Dakyns, was born in the island of St. Vincent, West Indies. In 1845 the family removed to England, and settled at Rugby, where J. R. Dakyns received his early education. In 1855 he proceeded to Trinity College, Cambridge; four years later he gained the position of twenty-seventh Wrangler in the Mathematical Tripos; and during the next two years he was engaged in teaching. Mathematics was a subject at all times of great interest to him, but Physical Geography likewise had its attractions. Hills and mountains exerted a magnetic influence on him, and the contemplation of these great features probably led him to the study of Geology. Eventually he found a congenial outdoor profession on the staff of the Geological Survey. He joined as an Assistant Geologist on January 16, 1862, and was promoted to the rank of Geologist on January 1, 1868.

In the course of his field-work he was principally occupied in the West Riding of Yorkshire and bordering tracts of Derbyshire, Lancashire, and Westmorland, and for a few years in the East

Riding. The results of his labours are given on the Geological Survey maps, and (as part author) in the memoirs on North Derbyshire (1869), the Yorkshire Coal-field (1869 and 1878), Leeds and Tadcaster (1870), Dewsbury, Huddersfield, and Halifax (1871), the Burnley Coal-field (1875), Bradford and Skipton (1879), Bridlington Bay (1885), York and Hull (1886), Driffield (1886), Kendal and Sedbergh (2nd ed., 1888), Ingleborough (1890), Mallerstang (1891), and Appleby (1897). On the mountains and uplands of the Lower Carboniferous rocks Dakyns was in his element, whereas when surveying for a time in the lowlands of Holderness he was by no means so buoyant in spirits. On the completion of the 1 inch geological map of England and Wales in 1884 he was transferred to the Scottish branch of the Geological Survey, and was engaged for ten years in mapping parts of the Forest of Athole, the country westwards to the borders of Argyllshire, and that around Loch Lomond in the counties of Stirling and Dumbarton. So far as mountain scenery was concerned Dakyns was in a kind of paradise, but the uncertainties of the geology sorely taxed him, and he was heard on one occasion to remark that hell was paved with Highland schists.

In conjunction with Dr. Teall he communicated to the Geological Society in 1892 an important paper "On the Plutonic Rocks of Garabal Hill and Meall Breac".

In 1894 Dakyns was transferred to South Wales to take part in the re-survey, on the 6 inch scale, of the Coal-field and bordering rocks. There he rejoiced in mapping the hilly ground of Old Red Sandstone and Lower Carboniferous rocks around Abergavenny, and he contributed to the memoir on that area, which was published in 1900.

He retired from the Geological Survey on April 30, 1896, soon after attaining the age of 60, and took up his residence at Snowdon View, Beddgelert, where he spent a pleasant and happy time geologizing in that mountain region. He re-mapped on the 6 inch scale the greater part of Snowdon, together with much of the adjacent country; and his maps and notes embody important revisions and additions to the knowledge of the district. It is much to be desired that this work should see the light; and as one of his intimate friends is, we understand, about to complete the parts left unfinished, we may hope that this will be accomplished before long. Through the results of a chill his active life was terminated after a brief illness, in his 75th year.

Although he never became a Fellow of the Geological Society, Dakyns communicated to that Society in 1872 a paper "On the Glacial Phenomena of the Yorkshire Uplands"; he was a frequent contributor to the Geological Magazine, on subjects relating more especially to Carboniferous and Igneous rocks, to Glacial Phenomena and Cave-deposits, and he was author also of papers published by the Yorkshire Geological and Polytechnic Society. Extremely original in character, and very widely read, intercourse with him possessed unusual fascinations; moreover, being full of sympathy for all living beings, and a staunch friend, he was endeared to all who had the privilege of his acquaintance.

H. B. W. & E. G.

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